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THE CHEMICAL COMPOSITION OF PHILIPPINE MUSHROOMS

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ELEVEN PLATES

The importance of mushrooms as an article of diet and of commerce is recognized everywhere, and the Philippines import large quantities of them from Japan and China. In view of the increasing use and importation of foreign mushrooms, it becomes important to know how to culture not only foreign species but also some of the important kinds which are found growing wild in many places of the Islands.

The culture and chemical composition of mushrooms have been studied abroad, but little similar work has been done in the Philippines. Vicencio (1917) reported on mushroom culture in the Philippines, but he gave only meager information about the native methods.

The senior author (1931) reported some analyses of Philippine mushrooms, with their different local names and a brief account of the edible and poisonous species. He also made certain suggestions for collecting wild mushrooms and important recommendations regarding the collection and sale of mushrooms in

order to prevent or reduce to the minimum the not few cases of mushroom poisoning which are reported from time to time from various parts of the Philippines.

The Philippines is especially noted for the number of its mushroom species, many of which, according to E. B. Copeland (1905) are edible. It is the object of this article to report the proximate chemical and inorganic composition of the commonest edible Philippine mushrooms in order to determine their food value.

The samples used in this study were collected in and around the vicinity of the College of Agriculture, University of the Philippines, Los Baños, Laguna. The fresh samples collected were at once submitted to the Department of Plant Pathology for identification. Fresh specimens were also placed in preserving fluid consisting of hydrochloric acid, alcohol, and water. This preserving fluid was found to be satisfactory in preserving the specimens for identification purposes. To Mr. Jose M. Mendoza, mycologist of the Bureau of Science, who has kindly consented to verify the identification of specimens reported in this study, the authors desire to express their great appreciation. Some imported mushrooms from China, Japan, and France were analyzed and compared, as to chemical composition, with Philippine species.

Species of mushrooms studied

1. *Psaliota* (*A.*) *campestris* Fr.; imported variety in cans (champinion).
   a. Solid portion.
   b. Liquid portion.
2. *Psaliota* (*A.*) *campestris;* Philippine variety A.
3. *Psaliota* (*A.*) *merrillii* Copel. B.
4. *Psaliota* (*A.*) *perfuscus* Copel.; fairy ring mushroom or lawn mushroom.
5. *Auricularia auricula-judae* (Linn.) Schroet.; taingang-daga (Tag.), imported from China.
6. *Auricularia* sp.
7. *Hirneola affinis* (Jungh.) Bres.
8. *Auricularia polytricha* Montagne.
9. *Collybia albuminosa* (Berk.) Petch.; cabuten punsó (Tag.), óong ti bontón (Il.).
10. *Collybia* sp.; mamarang (Tag.), man-nagado (Il.).
11. *Cortinellus* sp.; from China.
12. *Cortinellus Shiitake* Schroet.; imported from Japan.
13. *Lepiota cepaestipes* Fr.
14. *Lepiota chlorospora* Copel.; payong ajas (Tag.).
15. *Lentinus squarrosulus* Mont.; kulat-kulat (Tag.).
16. *Lentinus exilis* Klotz.; kulat-kulat (Tag.).

Species of mushrooms studied—Continued

17. *Pleurotus ostreatus* Jacq.; an-andáp (Il.), alitáp-táp (Tag.).
18. *Lentinus* sp.; curly; kulot-kulot (Tag.).
19. *Marasmius* sp.; small, orange, umbrella shaped.
20. *Lentinus* sp.; kulat-kulat (Tag.).
21. *Pleurotus opuntiae* (Dur. et Lev.) Sacc.
22. *Pleurotus limpidus* Fr.; an-andáp (Il.), alitáp-táp (Tag.).
23. *Pleurotus* sp.; an-andáp (Il.), alitáp-táp (Tag.).
24. *Lycoperdon lilacinum* Copel.; puffball; para-para (Il.).
25. *Volvaria esculenta* Bres.; kabuteng saguing, kabuting guiniican (Tag.).
26. *Galera* sp.
27. *Pholiota* sp.
28. *Stereum* sp.

METHODS OF ANALYSIS

Excepting for those which were modified by the senior author (1931), the Official and Tentative Methods of Analyses (1931) were used.

The results are given in Table 1. These figures are averages of at least two concordant determinations. The moisture content, as can be seen in the table, varies from 88.03 per cent for *Pleurotus opuntiae* A to 98.02 per cent for *Hirneola affinis.* (white gelatinous), giving an average of 87.30 per cent for the Philippine mushrooms studied. The canned mushrooms contain 92.58 per cent moisture for the solid portion and 97.60 per cent for the liquid portion.

To secure a better idea of the differences between the Philippine mushrooms studied and the imported species, the results in Table 1 were converted into terms of dry basis. These data are given in Table 2. It can be seen from the table that for Philippine mushrooms analyzed the ash varies from 4.24 per cent for *Lentinus squarrosulus* to 25.72 per cent for *Collybia* sp. (mamarang), giving an average of 11.19 per cent. For the imported mushrooms, excluding the canned species, it varies from 6.05 per cent for *Cortinellus Shiitake* Schroet. to 9.41 per cent for *Auricularia auricula-judae* (Linn.) Schroet. giving an average of 7.88 per cent. From these figures we see that there is a wide range in the mineral content of Philippine mushrooms, fourteen of twenty-three species analyzed having a higher mineral content than the imported varieties and the rest about the same values. The canned mushrooms contained 18.60 per cent as for the solid portion and 55 per cent for the liquid portion. These exceptionally high figures were found on analysis to be due mostly to the added salt in the preserving fluid.

The protein content varies from 6.04 per cent of *Auricularia polytricha* to 65.69 per cent for *Lycoperdon lilacinum* Copel. (puffballs), giving an average of 28.35 per cent for the Philippine mushrooms analyzed. Protein in the imported varieties varies from 11.59 per cent for *Auricularia auricula-judae* (Linn.) Schroet. from China to 27.10 per cent for *Cortinellus Shiitake* Schroet. from Japan, giving an average of 17.72 per cent for imported materials. The canned mushrooms gave 62.40 per cent protein for the solid portion and 15.83 per cent for the liquid portion. From the table we can see that four species of the Philippine mushrooms studied contain less protein than the imported mushrooms, eight species contain about the same amount, and the rest have higher protein contents. On the average, the Philippine mushrooms studied have a higher protein content than the imported species.

The fat content of Philippine mushrooms analyzed varies from 0.59 per cent for *Lentinus* sp. (curly) to 20.63 per cent for *Volvaria esculenta* Bres. (kabuteng saguing), giving an average of 5.37 per cent. The imported mushrooms contain from 0.86 per cent for *Pleurotus ostreatus* from China to 2.40 per cent for *Cortinellus Shiitake* Schroet. from Japan, giving an average of 1.63 per cent. The canned mushrooms gave 5 per cent fats for the liquid portion and 0.40 per cent for the solid portion.

The crude-fiber content of Philippine mushrooms varies from 6.96 per cent for *Psaliota* (*A.*) *merrillii* B to 36.83 per cent for mushrooms from a coffee plantation, giving an average of 15.08 per cent, whereas the same constituent varies from 6.92 per cent for *Auricularia auricula-judae* (Linn.) Schroet. from China to 14.72 per cent for *Cortinellus* sp. (Chinese mushrooms), giving an average of 10.87 per cent for the imported species. The canned mushrooms gave a crude-fiber content of 12.40 per cent.

The nitrogen-free extract for Philippine mushrooms varies from 2.35 per cent for *Pleurotus limpidus* B to 66.07 per cent for *Auricularia politricha* (brown top, white bottom), giving an average of 38.77 per cent for Philippine species. For the imported mushrooms it varies from 50.40 per cent for *Cortinellus Shiitake* Schroet. from Japan to 20.65 per cent for *Pleurotus ostreatus* from China, giving an average of 62.64 per cent nitrogen-free extract for the imported species. The canned mushroom gave 24.17 per cent nitrogen-free extract for the liquid portion and 6.20 per cent for the solid portion. In this constituent the Philippine mushrooms are lower than those of the imported species.

The calorific or fuel value of Philippine mushrooms varies from 1,923 calories per kilo to 4,170 calories per kilo of *Volvaria esculenta* Bres., giving an average of 3,249 calories per kilo. For the imported species it varies from 3,292 calories per kilo for *Cortinellus* sp. (Chinese mushroom) to 3,539 for *Pleurotus ostreatus* from China, giving an average of 3,447 calories. The canned species gave a calorific value of 2,850 calories per kilo for the solid and 2,105 calories per kilo for the liquid portion.

The inorganic analysis of the ash constituents of Philippine species reveal interesting facts. The ash constituents determined are SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, P_2O_5, S, and Cl. The results are given in Table 3. Averaging the figures for Philippine species, imported air dry, and canned species, a comparison of the ash constituents is given in Table 4. From these figures we find that, on the average, Philippine mushrooms are lower in silica, magnesium, sodium, potassium, and sulphur content than the imported mushrooms, but higher in iron, aluminum, calcium, and phosphorus. The canned mushrooms are exceptionally high in iron, sodium, and chlorine.

SUMMARY AND CONCLUSIONS

1. Twenty-three species of Philippine mushrooms and five imported species were analyzed.

2. On the average the Philippine mushrooms studied were found to be higher in mineral content, protein, and fat than the imported mushrooms but lower in crude fiber and carbohydrates.

3. With the exception of six species the Philippine mushrooms studied have about the same food value as the imported species and some have even more.

4. Six of the widely known and used varieties; namely, *Psaliota* (*A.*) *campestris,* Philippine variety A, *Psaliota* (*A.*) *merrillii* Copel. B, *Hirneola affinis* (white gelatinous), *Auricularia polytricha* (brown top and white bottom), *Collybia albuminosa* (Berk.) Petch, *Lycoperdon lilacinum* Copel. (puffball), and *Volvaria esculenta* Bres. (kabuteng saguing), have higher food value than the imported species.

5. Canned mushrooms have low calorific value compared with many of the Philippine species studied.

6. On the average, the Philippine mushrooms studied are higher in iron, calcium, and phosphorus content than the imported mushrooms.

7. Canned mushrooms are exceptionally high in iron and sodium chloride content.

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TABLE 1.—*The proximate chemical composition of Philippine and imported mushrooms (fresh basis)*

Kind	Moisture	Ash	Proteins N×6.25	Fats (ether extract)	Carbohydrates		Calorific value per kilo
					Crude fiber	N. F. E.	
1. *Psaliota* (*A.*) *campestris* Fr.; imported variety in cans (champinion):	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	
a. Solid portion	92.58	1.38	4.63	0.03	0.92	0.46	211
b. Liquid portion	97.60	1.32	0.38	0.12	.....	0.58	51
2. *Psaliota* (*A.*) *campestris*; Philippine variety A	78.30	1.66	10.13	1.37	2.02	6.52	810
3. *Psaliota* (*A.*) *merrillii* Copel. B	89.02	1.09	5.86	0.17	0.76	3.60	383
4. *Psaliota* (*A.*) *perfuscus* Copel.; fairy ring mushroom or lawn mushroom	90.60	1.02	4.71	0.20	1.04	2.43	311
5. *Auricularia auricula-judae* (Linn.) Schroet.; taiñgang-daga (Tag.), imported from China	16.40	7.87	9.69	1.22	5.79	59.03	2,931
6. *Auricularia* sp.	89.07	0.51	0.66	0.91	2.16	6.69	386
7. *Hirneola affinis* (Jungh.) Bres.	98.02	0.22	0.19	0.27	0.23	1.07	77
8. *Auricularia polytricha* Montagne	90.45	0.57	0.60	0.93	1.14	6.31	370
9. *Collybia albuminosa* (Berk.) Petch.; cabuteng punsó (Tag.), óong ti bontón (Il.)	89.93	0.79	2.96	0.40	0.81	5.11	368
10. *Collybia* sp.; mamarang (Tag.), man-nagado (Il.)	95.18	1.24	0.32	0.20	0.69	2.37	129
11. *Cortinellus* sp.; from China	19.49	4.87	20.82	2.86	10.89	40.57	2,777
12. *Cortinellus Shiitake* Schroet.; imported from Japan	18.37	5.30	16.29	0.97	12.02	48.05	2,687
13. *Lepiota e. paestipes* Fr.	79.19	2.02	4.81	0.60	2.41	10.97	703
14. *Lepiota chlorospora* Copel.; payong ajas (Tag.)	91.32	1.08	4.38	0.10	0.79	2.33	284
15. *Lentinus squarrosulus* Mont.; kulat-kulat (Tag.)	70.77	1.56	2.44	0.99	6.33	17.91	926
16. *Lentinus exiles* Klotz.; kulat-kulat (Tag.)	71.71	1.20	4.52	0.60	9.19	12.78	765
17. *Pleurotus ostreatus* Jacq.; an-andáp (Il.), alitáp-táp (Tag.)	10.65	5.88	12.04	0.86	7.44	63.13	3,162
18. *Lentinus* sp.; curly; kulat-kulat (Tag.)	61.88	0.97	1.56	0.05	1.44	4.30	245
19. *Marasmius* sp.; small, orange, umbrella shaped	9.35	1.55	3.09	0.76	1.99	3.26	831
20. *Lentinus* sp.; kulat-kulat (Tag.)	0.26	1.13	3.57	0.40	3.39	11.25	645
21. *Pleurotus opuntiae* (Dur. et Lev.) Sacc.	68.03	5.04	4.07	0.78	2.44	19.64	1,045
22. *Pleurotus limpidus* Fr.; an-andáp (Il.), alitáp-táp (Tag.)	92.98	0.38	3.88	0.66	1.94	0.16	227
23. *Pleurotus* sp.; an-andáp (Il.), alitáp-táp (Tag.)	94.71	0.73	1.00	0.05	0.86	2.65	154
24. *Lycoperdon hiacinum* Copel.; puffball; para-para (Il.)	89.39	0.82	6.67	0.79	1.30	0.73	389
25. *Volvaria esculenta* Bres.; kabuteng saguing, kabuteng guinilican (Tag.)	91.13	1.18	4.35	1.83	0.99	0.52	370
26. *Galera* sp.	93.17	1.31	1.71	0.47	0.87	2.47	215
27. *Pholiota* sp.	91.50	1.07	2.94	0.49	3.13	0.87	202
28. Sterum sp.	92.16	1.80	1.66	0.09	2.48	1.81	151

TABLE 2.—*The proximate chemical composition of Philippine and imported mushrooms (dry basis)*

Kind	Moisture	Ash	Proteins N×6.25	Fats (ether extract)	Carbohydrates		Calorific value per kilo
					Crude fiber	N. F. E.	
1. *Psaliota (A.) campestris* Fr.; imported variety in cans (champinion):	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	
a. Solid portion	92.58	18.60	62.40	0.40	12.40	6.20	2,850
b. Liquid portion	97.60	55.00	15.83	5.00	.....	24.17	2,105
2. *Psaliota (A.) campestris*; Philippine variety A	78.30	7.65	46.68	6.31	9.31	30.05	3,733
3. *Psaliota (A.) merrillii* Copel. B	89.02	9.93	48.85	1.51	6.96	32.75	3,486
4. *Psaliota (A.) perfuscus* Copel.; fairy ring mushroom or lawn mushroom	90.60	10.85	50.10	2.10	11.04	25.91	3,312
5. *Auricularia auricula-judae* (Linn.) Schroet.; taiñgang-daga (Tag.), imported from China	16.40	9.41	11.59	1.46	6.92	70.62	3,506
6. *Auricularia* sp.	89.07	4.67	6.04	8.33	19.76	61.20	3,532
7. *Hirneola affinis* (Jungh.) Bres.	98.02	11.11	9.60	13.64	11.62	54.03	3,877
8. *Auricularia polytricha* Montagne	90.45	5.97	6.28	9.74	11.94	66.07	3,872
9. *Collybia albuminosa* (Berk.) Petch.; cabuteng punsó (Tag.), óong ti bontón (Il.)	89.93	7.85	29.44	3.97	8.09	50.65	3,653
10. *Collybia* sp.; mamarang (Tag.) man-nagado (Il.)	95.18	25.72	6.72	4.22	14.38	48.96	2,675
11. *Cortinellus* sp.; from China	19.49	6.05	27.10	2.93	13.52	10.40	3,450
12. *Cortinellus Shiitake* Schroet.; imported from Japan	18.37	6.49	18.73	1.19	14.72	58.87	3,292
13. *Lepiota cepaestipas* Fr.	79.19	9.71	23.11	2.86	11.58	52.74	3,376
14. *Lepiota chlorospora* Copel.; payong ajas (Tag.)	91.32	12.44	50.41	1.19	9.05	26.87	3,281
15. *Lentinus squarrosulus* Mont.; kulat-kulat (Tag.)	70.77	5.34	8.75	3.39	21.66	61.26	3,170
16. *Lentinus exilis* klotz.; kulat-kulat (Tag.)	71.71	4.24	15.97	2.12	32.48	45.19	2,705
17. *Pleurotus ostreatus* Jack.; an-andáp (Il.), alitáp-táp (Tag.)	10.65	6.58	13.48	0.96	8.33	70.65	3,537
18. *Lentinus* sp.; curly; kulat-kulat (Tag.)	19.68	11.16	18.75	0.59	17.19	52.31	2,968
19. *Marasimius* sp.; small, orange, umbrella shaped	89.35	14.55	29.06	7.14	18.65	30.60	3,110
20. *Lentinus* sp.; kulat-kulat (Tag.)	80.26	5.72	18.09	2.03	17.17	56.99	7,171
21. *Pleurotus opuntiae* (Dur. et Lev.) Sacc.	58.03	15.76	12.72	2.37	7.63	61.52	3,264
22. *Pleurotus limpidus* Fr.; an-andáp (Il.), alitáp-táp (Tag.)	92.98	5.34	55.27	9.40	27.64	2.35	3,237
23. *Pleurotus* sp.; an-andáp (Il.), alitáp-táp (Tag.)	94.71	13.80	18.90	0.95	16.26	50.09	2,917
24. *Lycoperdon lilacinum* Copel.; puffball; para-para (Il.)	99.39	7.73	65.59	7.45	12.25	6.88	3,668
25. *Volvaria esculenta* Bres.; kabuteng saguing, kabuteng guiniican (Tag.)	91.13	13.30	49.04	20.63	11.16	5.87	4,170
26. *Galera* sp.	93.17	19.18	25.03	6.88	12.81	36.10	3,146
27. *Pholiota* sp.	91.50	12.59	34.57	5.78	36.83	10.24	2,374
28. *Sterum* sp.	92.16	22.96	21.13	1.18	31.63	23.09	1,923

TABLE 3.—*Inorganic constituents of mushrooms based on ash*

Kind	Ash, dry basis	Inorganic constituents based on ash										
		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	S	Cl	Total
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Kabuteng punsó; *Collybia albuminosa*	7.85	14.34	7.10	0.95	3.86	5.04	9.10	17.33	39.92	1.35	trace	96.99
Kabuteng saguing; *Volvaria esculenta*	13.20	15.23	4.47	0.99	2.35	0.92	15.37	24.76	30.14	1.42	3.85	99.50
Puffballs; *Lycoperdon lilacinum*	7.73	5.84	1.50	1.19	1.76	1.61	9.46	29.29	48.01	0.62	trace	99.28
Shiitake; *Cortinellus Shiitake*	6.05	9.28	5.69	0.71	2.73	6.77	24.04	24.82	19.07	3.91	1.20	98.22
Chinese mushroom; *Cortinellus* sp	6.49	15.17	6.07	0.33	3.59	7.05	21.17	27.37	16.41	2.21	trace	99.37
Kulat-kulat; *Lentinus exilis*	5.24	11.07	6.44	0.75	3.51	1.89	21.38	29.65	22.45	1.19	trace	98.13
Taiñgang daga; *Auricularia* sp	4.67	9.04	12.65	2.33	11.05	7.57	6.62	17.77	29.89	2.17	trace	99.09
French mushroom; *Psaliota (A.) campestris*, liquid [a]	55.00	2.25	0.30	30.45	2.34	1.00	40.30	3.41	5.15	2.50	(b)	.....
French mushroom; *Psaliota (A.) campestris*, solid	18.60	8.96	7.91	6.22	3.11	0.89	42.58	4.02	8.22	2.08	(b)	.....
Mushroom from coffee plantation; *Pholiota* sp	12.59	4.01	4.01	9.73	12.42	1.02	23.64	5.44	33.04	2.03	2.74	98.08
Payong-ajas; *Lepiota chlorospora;* poisonous	12.44	3.35	14.88	10.05	4.19	1.52	20.40	6.98	33.19	2.53	1.15	98.24
Lepiota cepaestipes; poisonous	9.71	0.92	9.61	5.03	0.91	3.14	13.59	27.49	33.19	2.51	(b)	.....
Marasmius sp.; small, orange, umbrella shaped	14.55	16.24	7.91	3.71	3.09	1.35	20.30	21.50	22.75	1.95	1.57	100.37
Psaliota (A.) campestris; Philippine variety	9.93	2.52	5.84	1.84	6.14	0.67	33.21	14.62	27.33	1.39	6.45	100.01
Kulat-kulat; *Lentinus* sp	5.72	14.41	8.66	13.88	2.11	2.94	6.73	18.33	24.77	1.03	(b)	.....

[a] Imported canned mushrooms from France.

[b] Not determined.

TABLE 4.—*Ash constituents of the different kinds of mushrooms (averages)*

Constituent	Philippine	Imported	Canned
	Per cent	*Per cent*	*Per cent*
SiO_2	8.82	12.23	5.61
Al_2O_3	7.55	5.88	4.11
Fe_2O_3	4.59	1.52	18.34
CaO	4.65	3.16	2.73
MgO	2.52	6.91	0.95
Na_2O	16.35	22.61	41.44
K_2O	19.38	26.20	3.72
P_2O_5	31.36	17.74	6.69
S	1.65	3.06	2.29

ILLUSTRATIONS

Plate I

(*a*) *Psaliota* (*A.*) *campestris* Fr.
(*b*) *Psaliota* (*A.*) *campestris*, Philippine variety A.

Plate II

(*a*) *Psaliota* (*A.*) *merrillii* Copel. B.
(*b*) *Psaliota* (*A.*) *perfuscus* Copel.

Plate III

(*a*) *Auricularia auricula-judae* (Linn.) Schroet. imported from China
(*b*) *Hirneola affinis* (Jungh.) Bres.

Plate IV

(*a*) *Auricularia polytricha* Montagne.
(*b*) *Collybia albuminosa* (Berk.) Petch.

Plate V

(*a*) *Collybia* sp. (mamarang).
(*b*) *Lepiota cepaestipes* Fr.

Plate VI

(*a*) *Lepiota chlorospora* Copel. (payong ajas).
(*b*) *Lentinus exilis* Klotz.

Plate VII

(*a*) *Lentinus squarrosulus* Mont.
(*b*) *Pleurotus ostreatus* Jacq.

Plate VIII

(*a*) *Marasmius* sp.
(*b*) *Panus* sp.

Plate IX

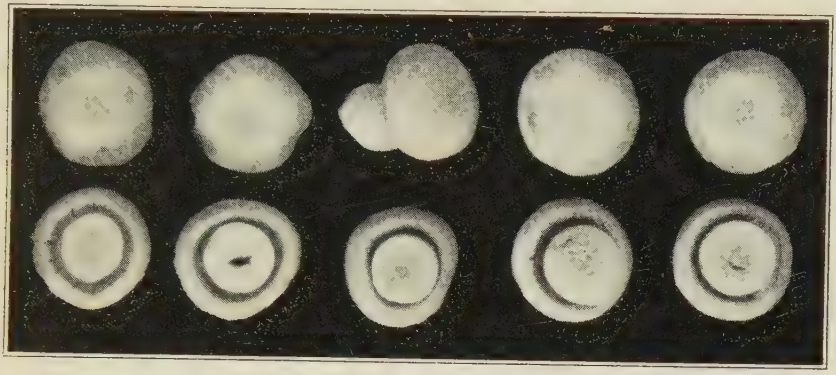
(*a*) *Pleurotus opuntiae* (Dur. et Lev.) Sacc.
(*b*) *Lycoperdon liliaceum* Copel.; puffballs.

Plate X

(*a*) *Volvaria esculenta* Bres.; kabuting saguing.
(*b*) *Galera* sp. from dead coconut tree.

Plate XI

(*a*) *Pholiota* sp. from coffee plantation.
(*b*) *Stereum* sp. from rotten wood buried in the ground.

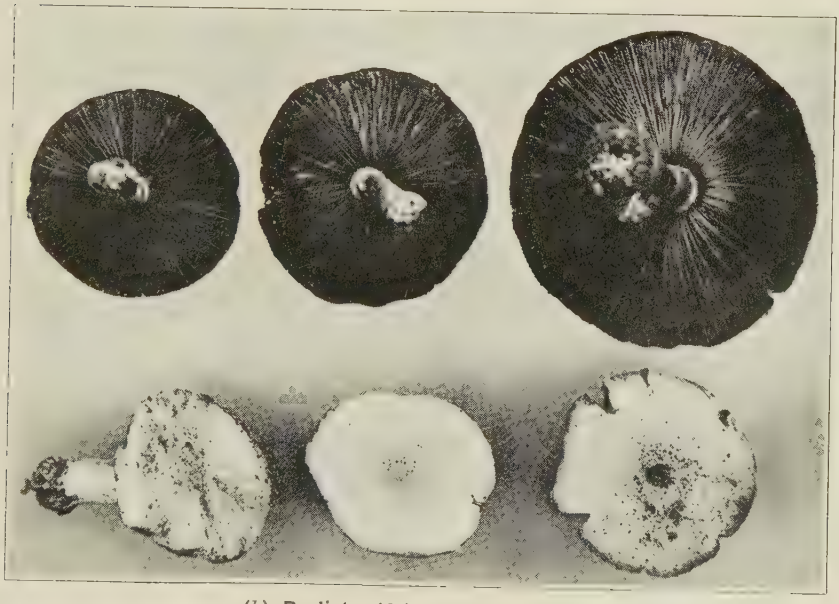


(*a*) Psaliota (A.) campestris Fr.

(*b*) Psaliota (A.) campestris, Philippine variety A.

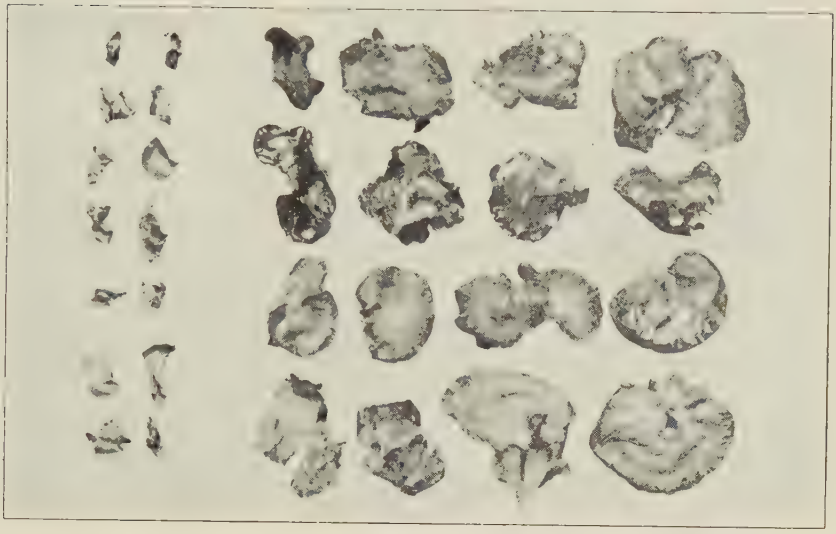
PLATE I.

(*a*) Psaliota (A.) merrillii Copel. B.



(*b*) Psaliota (A.) perfuscus Copel.

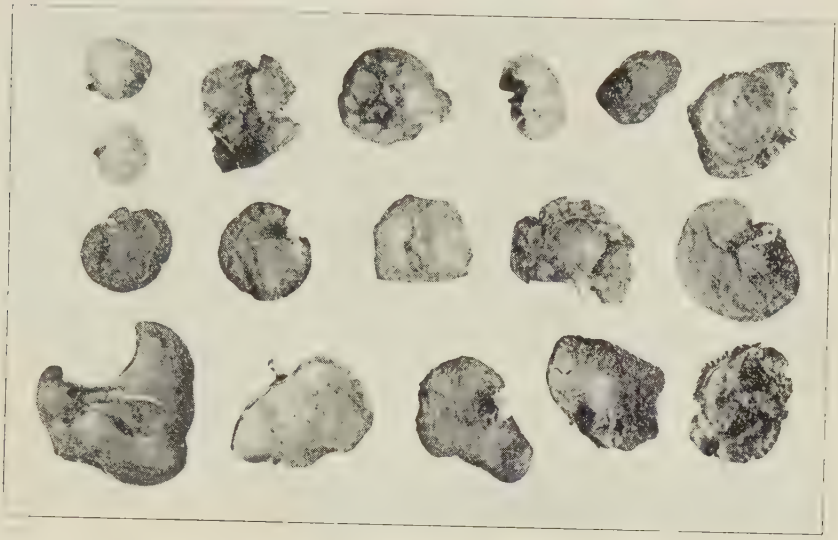
PLATE II.



(*a*) Auricularia auricula-Judae (Linn.) Schroet. imported from China.

(*b*) Hirneola affinis (Jungh.) Bres.

PLATE III.

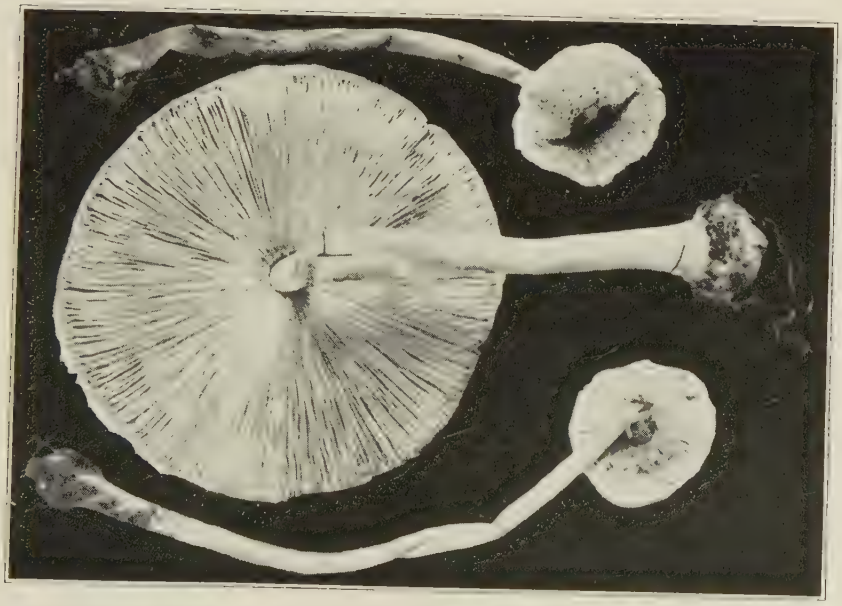


(*a*) Auricularia polytricha Montagne.

(*b*) Collybia albuminosa (Berk.) Petch.

PLATE IV.

(*a*) Collybia sp. (mamarang).



(*b*) Lepiota cepaestipes Fr.

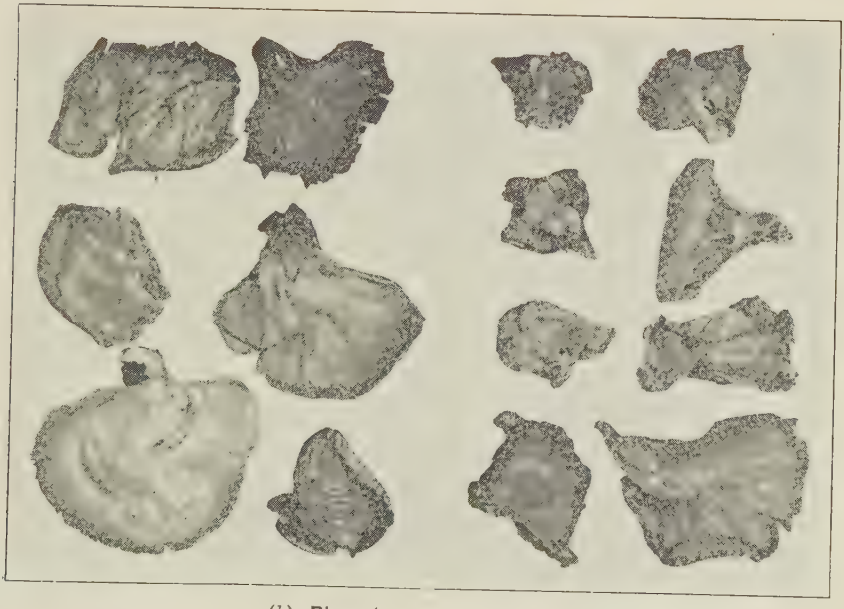
PLATE V.

(*a*) Lepiota chlorospora Copel. (payong ajas).

(*b*) Lentinus exilis Klotz.

PLATE VI.

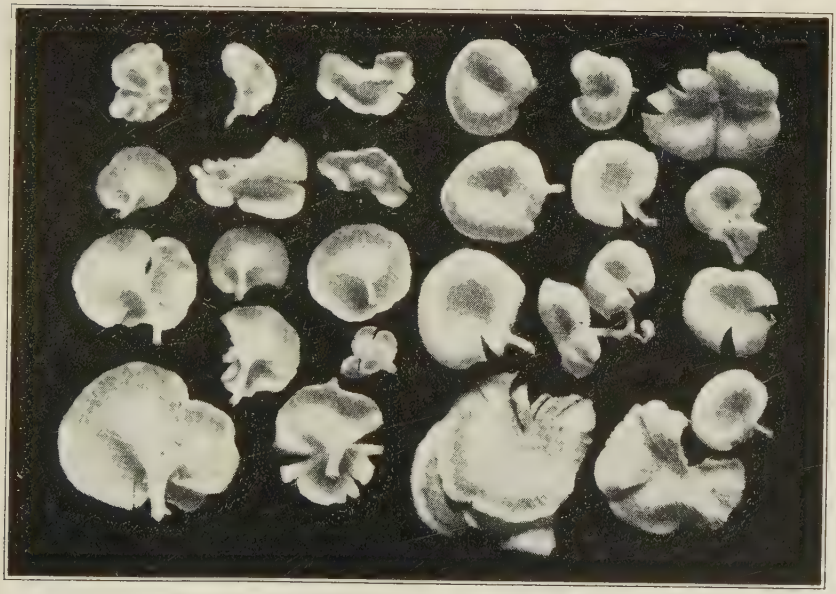
(*a*) Lentinus squarrosulus Mont.



(*b*) Pleurotus ostreatus Jacq.

PLATE VII.

(*a*) Marasmius sp.



(*b*) Lentinus sp.

PLATE VIII.

(*a*) Pleurotus opuntiae (Dur. et Lev.) Sacc. A.

(*b*) Lycoperdon lilacinum Copel.; puffballs.

PLATE IX.

(*a*) Volvaria esculenta Bres.; kabuteng saguing.

(*b*) Galera sp. from dead coconut tree.

PLATE X.

(*a*) Pholiota sp. from coffee plantation.

(*b*) Stereum sp. from rotten wood buried in the ground.

PLATE XI.

THE VALUE OF PHILIPPINE FRUITS AND VEGETABLES FOR THE PREPARATION OF FERMENTED AND UNFERMENTED PICKLES

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TWO PLATES

Pickling in general is defined as the preservation of food in brine or in vinegar with or without bacterial fermentation. The term "pickle" as used in this country refers to two distinct kinds—the first to the so-called native, quick-processed or unfermented variety and the other to the more expensive, imported, and fermented kind. Many home attempts at preparing fermented pickles such as mangoes and other fruits fail because of lack of proper knowledge of the subject. The softening of salted (*burong*) mango, radish, and other fruits and vegetables as commonly prepared in the homes is well known.

The manufacture of pickles is an important food industry. It is a well-known fact that while the preservation of vegetables and fruits in pickled form began as a household art, yet at present a great amount of the world's supply of pickles is produced in commercial plants. This is due to the great demand for this food product among all classes of people. The Philippines, according to reports of the Bureau of Customs, imports annually from two to three hundred thousand pesos worth of pickled fruits and vegetables.

Most of our fruits and vegetables are seasonal and in some parts of the Islands where they are produced in large quantities, the farmers, for lack of good markets and proper knowledge of utilization, are forced to sell them at very low prices, or else feed them to animals or just throw them away as waste. However, after the season, these same materials can only be procured at exorbitant prices. If proper means of preserving these fruits and vegetables can be found, much waste will be stopped and a more equable distribution of the products throughout the year and a more uniform range of prices will result. One of these means is the pickling of vegetables and fruits by suitable methods.

In the Philippine little is yet known and done about the preparation of fermented pickles from fruits and vegetables and it is for this reason that the present work is being carried on.

We have a very long list of vegetables and fruits which can be turned into attractive and good quality fermented pickles just as good if not better than the imported kinds.

If proper methods of pickling become generally known, we can not only decrease our imports on this product, but we shall also encourage the planting of more fruits and vegetables. The food value of these plant products is already well known.

GENERAL PRINCIPLES IN PICKLING

The spoiling of fruits and vegetables is not due directly to the action of air or of heat and is not simply a physical change, but to the growth of certain microscopic living organisms or bacteria, of which there are many kinds.

Many of the vegetables as they come from the field have on their surfaces both lactic acid bacteria and other organisms capable of causing spoiling. Brine or salt is added to vegetables or fruits in pickling in order to inhibit microörganisms capable of causing spoiling and to promote the growth and multiplication of the desirable lactic acid bacteria as well as to improve the flavor and texture of the resulting pickle. Lactic acid bacteria can grow in certain concentrations of salt and in fact, the presence of proper amounts is necessary for their proper growth and development. The brine extracts the vegetable juices which serve as foods for the lactic acid bacteria. The lactic acid produced and the salt added preserve the product, provided that the air is excluded. In the presence of air, however, aërobic microörganisms develop, and destroy the acid and as a result putrefaction takes place.

Exclusion of the air after lactic fermentation is complete is an essential part of the process.

MATERIALS AND EQUIPMENT USED IN PICKLING

MATERIALS

Water.—Soft water is best for pickling. Hard water should not be used, especially for fermented pickles, as the presence of large quantities of calcium and other salts found in many natural waters prevents the proper lactic acid formation, thus

interfering with the curing process. Iron in large amounts is also objectionable, as it causes blackening of the pickles.

Salt.—There are two kinds of salt generally used, the refined salt and the ordinary. The former is used mostly in unfermented slow-process pickles and the latter in fermented and unfermented quick-process pickles. The refined salt is too expensive and, besides, the ordinary clean rock salt is satisfactory.

A saturated salt stock solution is prepared in a big barrel by dissolving salt in tap water until a reading of 90° to 109° salometer is obtained. This salt stock, after proper dilution, is used in brining the fruits or vegetables. The dilution depends upon the materials to be fermented; the more watery the raw material the more concentrated the brine should be.

Vinegar.—Clacial acetic acid of about 99 per cent purity is used, since it is colorless and free from sediment. This can be diluted to give any solution of the desired percentage of acetic acid.

Sugar.—In making sweet pickles, refined sugar is used. Brown sugar produces a cloudy pickle solution even after it has been strained through a cloth bag.

Spices.—The flavor, odor, and appetizing taste of many kinds of pickles are due largely to the species added to the brine or vinegar; but spices should be used in moderation and should not completely conceal the flavor of the fruit or vegetable.

The spices most commonly used are whole cloves, coriander, black pepper, bay leaves, cinnamon, celery seed, turmeric, and mace. These may be purchased in bulk and may be mixed as desired. In this work, whole spices bought from local grocery stores were used.

Coloring and hardening agents.—It is the practice in some households to "green" pickles by heating them with vinegar in a copper vessel. In this treatment there is formed copper acetate, which is a poisonous substance. Foods "greened" with copper salts, all of which are poisonous, are regarded as adulterated and cannot be sold. The use of green leaves such as grape and sugar cane to improve the color of the pickles is of doubtful value.

Alum is often used for the purpose of making pickles firm. However, if proper methods are followed in pickling, the salt and lactic acid in the brine will produce the desired firmness

of the pickle product. Although alum will make pickles crisp, its use is objectionable.

PICKLE SOLUTIONS

Sour solution.—The sour pickle solution is made by diluting the glacial acetic acid to the desired acidity. Usually 3 to 4 per cent acidity is used.

Sweet solution.—Two kinds of sweet pickle solution were used and made up as follows:

1. To 1 liter of 3.5 per cent acetic acid were added sufficient refined sugar (about 200 grams) to read 20° Brix, and 1 tablespoon of whole spices.

2. To 1 liter of 4 per cent acetic acid were added 1 tablespoon of whole spices and sufficient refined sugar (about 500 grams) to read 50° Brix.

The spices were placed in a piece of cheesecloth and then suspended in the solution, which was kept at 70° C. for ten minutes and then the heated solution, including the spices, was set aside overnight. The spiced sweet vinegar solution was strained before using.

The acidity and the amount of sugar to be added may be altered to suit individual taste.

EQUIPMENT

Scales.—A balance and set of weights were used in weighing the ingredients.

Measures for liquid.—For measuring liquids such as brine solution, vinegar, syrup, and water, a quart measure or a quart or pint jar, a gallon measure, and graduated cylinders were used.

For household use a quart measure is useful. If such a measure is not available, a graduated cylinder or a quart or a pint jar may be used instead.

Salt hydrometer, or salometer.—A salt hydrometer is used for measuring the approximate percentage of salt in the brine. This apparatus may be purchased for about 2 pesos from a drug store or a firm dealing in chemical apparatus. It is graduated into the so-called salometer degrees; 100° indicates a saturated salt solution, or 26.5 per cent salt; and 0° is taken from water only. Salometer degree divided by four gives the approximate percentage of salt. A 40° salometer reading is therefore equivalent to approximately a 10 per cent salt solution. The following table taken from Joslyn and Cruess (1929) shows the salt

percentages and the corresponding salometer readings and amounts of salt required for one gallon of water to prepare solutions of the desired salometer reading.

Per cent salt	Salometer degrees	Ounces salt per gallon	Per cent salt	Salometer degrees	Ounces salt per gallon	Per cent salt	Salometer degrees	Ounces salt per gallon
1	3.8	1.3	10	37.7	14.2	19	71.7	30.0
2	7.6	2.6	11	40.5	15.8	20	75.5	32.0
3	11.3	4.0	12	45.3	17.5	21	79.2	34.0
4	15.1	5.3	13	49.1	19.1	22	83.0	36.1
5	18.9	6.7	14	52.8	20.8	23	86.8	38.2
6	22.6	8.1	15	56.6	22.6	24	90.6	40.4
7	26.4	9.6	16	60.4	24.4	25	94.3	42.7
8	30.2	11.1	17	64.2	26.2	26	100.0	46.1
9	34.0	12.7	18	68.0	28.1	.....	.....	.....

Cooking utensils.—In heating the pickles it is necessary to use aluminum, agate, or porcelain-lined kettles because of the chemical action of the acid in vinegar on most metallic vessels.

Containers.—For home use glass-top pint jars are satisfactory. The ordinary Mason jars provided with glass or porcelain covers are most desirable because zinc or other metallic caps are easily corroded by the vinegar and other acids in the brine. The zinc salts thus formed are poisonous. For commercial purposes different kinds of pickle bottles are generally used.

Siphon.—For determining the salt concentration or salometer reading of the brine solution of the fermenting vegetables or fruits it is necessary to transfer a part of the solution to a cylinder. To facilitate the transfer the device shown in fig. 1 was made.

Hand bottle capper.—A hand bottle capper was used. This capper cost 5 pesos.

EXPERIMENTAL

BLANCHING

Most vegetables are blanched before fermentation for the purpose of fixing and brightening their color. Generally, blanched vegetables of fruits improve in texture. Blanching is also done for cleansing purposes and for removing the objectionable odor or taste of some vegetables.

The vegetable or fruit is washed in tap water and then placed in a cheesecloth bag. The filled bag is immersed in boiling water, the time of immersion depending upon the texture of the material, but generally from two to five minutes is sufficient. After blanching, the vegetable or fruit is immediately placed in cold or cool running water.

FERMENTED FRUIT PICKLES

Freshly gathered, hard, firm, and mature fruits should be used. Small fruits may be used whole if desired. In most cases they are peeled, cut into halves, quarters, slices, or any desired shape. The peeled material is immediately dropped into a salt solution and allowed to ferment. The concentration of the brine solution varies from 40° salometer or 20 per cent salt, depending on the kind of fruits. Those fruits which are high in water content are fermented in stronger brine solution. During fermention the containers are kept full and the pickles well covered with brine at all times. To prevent the fruits from rising to the top of the brine, a screen made of bamboo (*asad*) is used. The stage of active fermenation continues for from one to three weeks. The quantity of lactic acid formed depends primarily upon the sugar content of the fruits being fermented, but it may be influenced by other factors such as temperature and strength of brine solution. The presence of acid is determined qualitatively by means of blue litmus paper and quantitatively by titration with a standard alkali solution. After fermentation is complete, as shown by the activity of the fermenting material, and more accurately by analysis, the fruit is ready to be made into either sweet or sour pickles.

The salt pickles prepared by this method are washed by being let stand in several changes of water until the excess salt is removed; or they may be placed in a vessel and set under tap water and a small stream allowed to flow into the vessel overnight. The pickled fruits are prepared like fruits for canning and are then packed into clean, dry jars. The jars are filled with the pickle solution and then processed in a water bath kept at 70° C., the length of time required for processing depending upon the kind of fruit.

For sour pickles, the fresh fruits are placed in a container and weak vinegar (2 per cent) is added. The volume should be sufficient to cover the fruit. They should be left in this vinegar for three to five days. After this treatment, the vinegar is raised to 3 per cent acidity or it may be replaced with a new 3 per cent vinegar solution. The fruits should be left in the vinegar for three to six days. The vinegar should finally be raised to 3.5 per cent acidity or stronger, if preferred. A few days in the last vinegar will complete the treatment of the pickles.

GUAVA

Some were cut into halves and the seeds removed, while the others were fermented whole. They were placed in separate containers, but an initial brine solution of 60° salometer was used in all cases. The fruits that were cut into halves reduced the brine solution to 45° salometer after four days, but the whole guavas reduced it to only 48°. The lactic acid formed was 0.46 per cent and 0.34 per cent, respectively. The fruits were made into sweet pickles. The texture and flavor of both were good.

HEVI

Four small barrels of hevi were prepared and fermented. In barrels 1 and 2 were fruits which were peeled and fermented whole. Barrels 3 and 4 contained peeled, sliced, and pitted hevi. All of them were started September 30, 1932.

To barrel 1 was added a brine solution of 50°. A week after, the reading dropped to 40°. After three weeks the reading was only 38°. Upon examination, the fruits were found to be soft. November 7 the reading was 38° and the fruits were still soft. November 10 salt was added so as to increase the concentration to 60° salometer. The reading dropped again to 57° November 14. The lactic acid was found to be 0.26 per cent. The fruits were so soft that they had to be discarded.

The fruits in barrel 2 had an initial brine solution of 60° salometer. From October 7 to the time the fruits were washed, November 14, the salometer reading varied from 57° to 59°. The lactic acid formed was 0.42 per cent. The seeds were removed from the fermented fruits, which were sliced and made into sweet pickles. The texture and flavor were good.

The contents of barrels 3 and 4 were also fermented in the same way as those of barrel 2.

PAPAYA

The fruits were peeled, pitted, and cut into small rectangles and other forms. November 18 the sliced fruits were placed in a barrel containing brine solution of 60° salometer. The next day the concentration was reduced to 40° and gradually dropped until, November 26, the hydrometer registered 37°. From that date there was a gradual decrease of concentration of salt until December 19 when the fruits were washed, the hydrometer reg-

istered 51°. The percentage of lactic acid formed was 0.082. The fermented fruits were tough, so they were cooked in steam until soft. They were used in the preparation of sweet and sour mixed pickles.

BALIMBING

After the edges were trimmed off the fruits were cut into segments and across the length, and placed in brine solution of 56° salometer for fermentation, which was started November 18. Readings were taken from time to time, and the brine concentration was maintained at not lower than 40° salometer. It may be noted from Table 1 that salt was added four times. From December 2 to December 19 the hydrometer readings varied from 43 to 45°. The fermented fruits were washed December 19 to remove the excess salt and then soaked in 4 per cent vinegar overnight. There was no discoloration, and the fruits were crisp and firm. The flavor was good. They were used in the preparation of sweet and sour mixed pickles.

FERMENTED VEGETABLE PICKLES

Vegetables are fermented in much the same way as fruits. Fermented vegetables owe their keeping quality mainly to lactic acid. Pickled products produced by fermentation are superior to all others in quality and appearance.

Vegetables properly prepared are placed in brine solution of from 40° to 80° salometer, depending upon their texture and water content. As soon as the vegetables are placed in the brine, osmotic action begins and continues until a state of equilibrium is established between the brine and the juices of the vegetables. This same action takes place in the case of fruits. Due to osmotic action the juice is drawn from the vegetables into the brine and the brine is taken up by the vegetables. At first the flow of juice outward is more rapid than the inflow of brine. This causes a slight shriveling of the vegetables. Later the inward flow is sufficiently rapid to cause the vegetable to become firm and plump again.

The juice that is drawn out of the vegetables contains, among other things, small amounts of sugar in solution. These sugars are used by the lactic acid. At the close of the fermentation period the vegetables are preserved in a mixture of brine and lactic acid.

Vegetables so treated are known as salt pickles or salt stock. They may be kept for a long period if properly protected or

they may be manufactured at once into the common types of edible pickles, such as sour and sweet pickles.

GREEN PEPPERS (SHORT VARIETY)

The materials were cut into halves and seeds removed. The materials thus prepared were washed with tap water and drained; then they were placed in a glass container and covered with a brine solution with an initial reading of 80° salometer. Up to November 7 the salometer reading remained almost constant. November 14, 1932, the salometer reading was 50° and the brine solution was neutral to litmus paper. The fermentation materials were washed and allowed to stand in water until the excess salt was removed. They were then soaked in a 4 per cent acetic acid solution overnight, and the next day the fermented peppers were packed and covered with a sweet pickle solution consisting of 3.5 per cent acetic acid plus sugar to read 44° Brix. There was a slight discoloration but the texture and flavor were good.

November 25, 1932, another batch of green peppers was used, but the initial reading of the brine was 60° instead of 80°. November 26, 1932, the salometer reading dropped to 44°. From that date to December 19 the brine solution was acidic to litmus paper. On titration the lactic acid was found to be 0.055 per cent. There was a slight discoloration. Texture and flavor were good. The fermented materials were used in the preparation of mixed pickles, both sour and sweet.

RED PEPPERS (LONG VARIETY)

December 12 red peppers were cut into halves and pitted and then immersed in brine solution of 54° salometer. The next day the reading dropped to 48°, and December 19 it was 43°. The lactic acid was found to be 0.0132 per cent. The peppers were washed, as usual, to remove the excess salt; then soaked in a 4 per cent acetic acid overnight, when they were ready for the preparation of mixed pickles. No fading of the red color was noticed. The texture was good, but the flavor was a bit too hot. Later experiments have shown that the biting taste can be removed by a longer period of fermentation.

AMPALAYA

Fresh green ampalaya was pitted and cut into rectangular pieces and across the length of the fruits, and then placed in a barrel containing brine of 60° salometer. After the first day,

September 27, the salometer reading was only 35°. September 28 the brine solution registered 48° salometer. From October 7 to November 14 the readings were almost constant, ranging from 52° to 53° salometer. Upon titration the lactic acid was computed to be 0.38 per cent. Like the rest they were washed, to remove the excess salt, and soaked in 4 per cent acetic acid overnight. The color of the fermented ampalaya was pale green. The texture and flavor were good. Some were put into vinegar of 44° Brix. Some were boiled in 4 per cent acetic acid in a copper container. The ampalaya assumed its original fresh color, but on account of the poisonous nature of the copper acetate this procedure is not to be recommended.

November 18 more apalaya was prepared and immersed in a brine solution of 56° salometer. November 19 the reading fell to 38°. It was claimed that below 40° salometer the vegetables were liable to spoil, so the brine concentration solution was increased to 48° November 26. November 27 the brine was again reduced to 36°, so some salt was added to increase it to 55° salometer. From November 28 to December 19 the readings were almost constant, ranging from 52° to 54° salometer. The lactic acid was found to be 0.026 per cent December 19. There was discoloration but the fermented vegetables were crisp and their flavor excellent. They were used in the preparation of sweet and sour mixed pickles.

BEANS

String beans.—The tips of the fresh materials were trimmed off and the beans cut in two lengthwise, washed, and immersed in a 40° brine solution. This was started September 26. September 27 the reading fell to 29° salometer. Salt was added to increase the reading to 58°. September 29 the reading was 49° salometer. From October 7 to November 14 the brine solution had a constant reading and a neutral reaction to litmus paper. After the excess salt had been removed, the beans were immersed in 4 per cent acetic acid, then packed and sweet pickle solution added. There was a slight discoloration, but the texture and flavor were good.

Green beans (*habichuelas*).—After the tips were cut off the beans were immersed in a brine solution having an initial reading of 40° salometer. The fermentation was started September 26. The next day the salometer reading was only 35°. In order to prevent the putrefaction of the material, the percentage of salt was increased to 12 per cent or a reading of 48°

salometer. September 28 there was a reduction of the salometer reading to 46°. From September 28 to the time the excess salt was removed on November 14, the reading ranged from 46° to 47° salometer. There was no lactic acid formed. A little discoloration resulted, but the texture and the flavor were good. They were made into sweet pickles.

Paayap.—The beans were prepared like the green beans, but a mat of grape leaves about an inch thick was placed at the bottom of a glass container before the beans were put in. Another layer of grape leaves was placed on top of the beans before a brine solution of 56° salometer was poured over the whole material. Fermentation was started November 18. November 26 the brine concentration was reduced to 33°. Salt was added to increase the reading to 43°. November 28 the reading was 45° salometer. There was an increase of 2° but the concentration was still lower than that of the initial brine solution. From that date of December 19 the different readings were almost constant, ranging from 44° to 45° salometer. December 19 the lactic acid was determined and found to be 0.059 per cent. The color faded a little, the texture was tough, and the flavor was poor. The beans were then cooked in steam until they softened somewhat. The texture was improved. The fermented materials were used in the preparation of sweet and sour mixed pickles.

Canadian Wonder Beans from Baguio.—These were prepared like the rest of the beans but fermented as whole beans. For the coloring agent sugar-cane leaves were used. The initial salometer reading of the brine solution used was 60°. November 28, or after two days' fermentation, the brine solution was 30° salometer. Salt was added to increase the salometer reading to 51°. From December 2 to December 19 the readings were constant. It may be seen from Table 1 that the lactic acid formed was 0.076 per cent. There was little fading in color. The texture and flavor were both good. The beans were used in the preparation of sweet and sour mixed pickles.

Some of the Canadian Wonder beans were blanched and fermented in brine solution having an initial reading of 52° salometer. This was started November 26, which was the same date as for the rest of the Canadian Wonder beans. November 28 the reading was 36°. The brine concentration was increased to 46°. From that date the salometer readings were constant, ranging from 45° to 46°. The lactic acid found was 0.064 per cent. There was also a discoloration, but the color of the beans

in general was better than that of the Canadian Wonder beans with which sugar-cane leaves were used as a coloring agent. The texture and flavor were good.

RADISHES

The radishes were peeled, quartered, washed, and placed in brine solution with an initial reading of 60° salometer. The fermentation was started September 26. The next day the reading dropped to 29°, and September 28 it rose to 50°, without extra salt being added. From October 7 to November 14 the reading varied from 51° to 53° salometer. The lactic acid was found to be 0.31 per cent. The excess salt was removed as usual, and the fermented material soaked in 4 per cent acetic acid overnight. The color was white and translucent. The radishes were very crisp in texture, and the flavor was excellent.

CUCUMBERS

The cucumbers were seeded, peeled, and cut into various sizes and forms. The fermentation was started November 18 with a brine solution of 56°. The next day, November 19, the reading suddenly dropped to 28°, so that salt had to be added to increase the brine concentration to 50° salometer. There was a gradual decrease of the percentage of salt until November 26, when the hydrometer registered only 25°. Again salt was added to increase the concentration to 49° salometer. November 28 the reading was 45° and was constant up to December 8; then rose to 47° by December 19. The lactic acid formed was 0.021 per cent. The fermented material was used in the preparation of sweet mixed pickles. The color was white and translucent. The cucumbers were crisp and their flavor was excellent.

SEGUIDILLAS

The seguidillas were cut in two. Some were treated with grape leaves and the rest with sugar-cane leaves. Both had an initial brine concentration of 60° salometer. Those with grape leaves decreased in the salt concentration gradually to 48° until they were washed, while those with sugar-cane leaves maintained their initial reading for more than a week. The fermentation of the seguidillas with sugar-cane leaves was so slow that the brine solution concentration was reduced only to 44° December 8. December 19, when the seguidillas was prepared for packing, the reading was 46° and the lactic acid 0.029 per cent. The seguidillas treated with grape leaves were darker in color than

those treated with sugar-cane leaves. Both were crisp in texture and of good flavor.

ONIONS (WHITE AND PURPLE VARIETIES)

After the outer skin was removed the onions were soaked in water for three days, the water being occasionally changed. They were then placed in brine solution with an initial concentration of 61° December 16. December 17 the reading dropped to 31° and was increased to 51° by adding salt. December 19 it dropped again and registered 49° on the hydrometer. The onions assumed a darkened color, but after immersion in 4 per cent acetic acid, the original color was restored. The onions were used in the preparation of sweet and sour mixed pickles.

MIXED PICKLES

In the preparation of mixed pickles, various combinations of vegetables are used, depending upon the mixture desired. In the United States and in Europe, onions, cauliflowers, green and red peppers, tomatoes, beans, and cucumbers are generally used.

QUICK-PROCESS FERMENTED PICKLES

Generally the materials are washed thoroughly and prepared like those for fermented pickles. The vegetables or fruits are then placed in the container and covered with brine of from 40° to 60° salometer. The materials are left in the brine solution for twenty-four hours. After brining, the vegetables or fruits are washed, to remove the excess salt, and then soaked in 4 per cent vinegar. These vegetables may be made into either sour or sweet pickles.

CUCUMBERS

Fresh materials were used. They were seeded, peeled, and sliced crosswise (about 0.25 inch thick), and the thin slices were immersed for five days in brine solution of 56° salometer. The final reading of the brine solution was 40° salometer. The excess salt was removed by allowing the pickles to stand in tap water for a few hours. A sweet pickle solution of 3.5 per cent acetic acid and 50° Brix heated with allspice at 70° C. was used. The finished products were processed for ten minutes at 70° C. The texture was crisp and the flavor good.

Another lot of large cucumbers was prepared November 25, 1932. The fresh materials were peeled as usual and cut into small rectangles. The initial brine concentration was 40° salo-

meter, or approximately 10 per cent salt. The next day the hydrometer reading fell to 25°. After the excess salt was removed they were packed and a pickle solution of 4 per cent acetic acid with sugar to make it 20° Brix was added. The finished product was processed for ten minutes at 70° C. The texture and the flavor were good.

EGGPLANTS

November 18 some eggplants were prepared like those for the fermented pickles. The cut eggplants were immersed for four days in an initial brine solution of 56° salometer. On the fourth day the salt concentration was found to be only 41°. The color faded. The eggplants were made into sweet pickles. Even after the processing for fifteen minutes the skin was tough. The flavor was fairly good.

SEGUIDILLAS

These vegetables were cut uniformly and blanched in boiling water for two minutes. They were then placed in a brine solution of 40° salometer overnight. There was a little discoloration of the material. After the excess salt had been removed, they were made into sweet pickles. The finished product was crisp and the flavor was good.

SLOW PROCESS UNFERMENTED PICKLES

The vegetables were washed and prepared ready for packing. They were placed in containers and the proper pickle solution added, care being taken to cover the vegetables completely. After two or three weeks they were ready for packing.

CUCUMBERS

Cucumbers of medium size were peeled and cut into thin sections crosswise. The seeds were removed and the slices covered with a solution consisting of 4 per cent acetic acid, plus refined sugar to make 20° Brix, with 1 cup refined salt per gallon. The acidity was titrated from time to time and was maintained at about 4 per cent. December 7, or after a period of twelve days, they were finally packed and processed for five minutes. The cucumbers turned soft, but the flavor was fairly good.

RADISHES

The fresh raw materials were washed and peeled and cut into quarters. A solution exactly the same as that used for the cucumbers was also used. The acidity was titrated from time to time, keeping it around 4 per cent. After a period of twelve

days they were bottled and processed for five minutes. The finished product was good both in flavor and texture.

PACKING AND PROCESSING

The appearance of the finished product depends largely upon the manner in which it is packed in the bottles. The various kinds of vegetables and fruits should be arranged in as neat and attractive a manner as possible. Bottles should not be filled entirely.

According to Chenoweth (1930), the processing is the most important operation in canning. No matter how carefully all other steps have been performed, if the processing is not thorough trouble is sure to result. Great skill is required to be able to process food sufficiently long to insure its keeping and at the same time to secure the maximum quality.

When glass-topped jars are used, place them in a water bath so that the water and the pickle solution are at the same level. Heat the water in the bath to from 70° to 80° C. for five to ten minutes, depending upon the material to be pasteurized. At the end of this period remove the containers from the bath and close the jars tightly. Invert the jars and allow them to cool in this position overnight.

If pickle bottles are used they are loosely corked and pasteurized by a similar method. At the end of the heating period, the bottles are removed from the bath and the corks seated tightly by the corking device. To prevent the entrance of air the corks should be sealed with a lacquer such as can be bought from stores dealing in paints and varnishes.

DISCUSSION OF RESULTS

The results of fermented and unfermented pickle experiments are recorded in Tables 1 and 2, respectively.

FERMENTED FRUIT PICKLES

All the fruits that were fermented proved to have good pickling qualities. A brine concentration of from 40° to 60° salometer was found satisfactory for fermenting guavas. It may be noted from Table 1 that by using such concentrations, lactic acid of 0.46 and 0.34 per cent was formed. The texture of the fruit after fermentation was fairly good.

Below 40° salometer, or approximately 10 per cent salt, hevi softens readily. It was found that after the fruits have softened the addition of more salt to increase the brine concentration

will not prevent further softening. Like guavas, hevi can be fermented in a brine solution of 50° to 60° salometer. The resulting pickled product was of a very good texture.

The native way of preparing papaya pickle is to grate the fruits or vegetables, blanch them in boiling water, and cover them with sweetened vinegar. In the present work it may be noted in Table 1 that papayas can be safely fermented in a brine solution of 50° salometer. Even at 40° salometer, or approximately 10 per cent salt, the sliced fruit did not soften.

Balimbing was fermented in a brine solution having an initial reading of 56° salometer. Due to the water content of the fruit the original brine concentration was diluted to 38° salometer. Table 1 shows that salt was added four times before the reading became constant at around 44° and 45° salometer. The reading was always fixed above 40° salometer because experimenters have found that most fruits and vegetables putrefy in brine solutions below such concentration. After a period of about one month, a final reading of 43° salometer was obtained, 0.098 per cent lactic acid was formed, and the fruits became firm and crisp.

FERMENTED VEGETABLE PICKLES; PEPPERS

As a result of the various trials it may be stated that peppers in general can be safely fermented in a brine solution having a concentration of from 45° to 50° salometer. It was found that at 70° salometer and above, fermentation was checked. This may be due to the fact that in such brine concentrations the lactic acid bacteria cannot thrive. The biting taste of peppers can be lessened by washing them well in several changes of tap water before fermenting, and also by proper curing.

AMPALAYA

Some ampalaya was prepared and fermented September 26 with an initial brine concentration of 60° salometer. On the next day so much of the salt had been absorbed by the vegetables that the salt solution was decreased to 35° salometer. No salt was added and on the second day, September 28, the reading was found to be 48°. The increase may have been due to the fact that some of the salt had been given off by the vegetables with the vegetable juice. From October 7 to November 14 the readings were around 52° and 53° salometer. The lactic acid formed was 0.38 per cent, and the pickled products had a good texture.

November 18 another trial was made. The brine solution used for fermentation had an initial brine concentration of 56° salom-

eter. The reading was kept around 53° and 54° for aperiod of one month, and the resulting product was good.

From these results it can be stated that ampalayas can be safely fermented in a salt solution of from 50° to 60° salometer.

BEANS

According to the results of fermenting various beans—such as, string beans, habichuelas, paayap, and Canadian Wonder beans from Baguio—it has been found that they need a lower concentration of salt solution. About 40° to 45° salometer is enough for fermentation. The use of grape leaves and sugar-cane leaves to preserve the green color is still of doubtful value. However, grape leaves are better than sugar-cane leaves. Blanching and proper long-time curing seems to be more effective in preserving the green color of the beans.

RADISHES

With these vegetables a brine solution of from 50° to 55° salometer is just right for fermentation without softening the texture. If the radishes are cured in salt solution of that range of concentration for from three to four weeks, a translucent white pickle will be produced.

CUCUMBERS

In most references cited in this paper, most of the authors used a salt solution of 60° salometer for fermenting cucumbers, but in these experiments it was found that a concentration of from 45° to 50° salometer was also safe to use.

SEGUIDILLAS

The range of brine concentration for fermenting varies from 45° to 50° salometer. There is not much lowering of the reading after the first day of immersion in the brine solution, so that if the initial reading is 50° salometer, the addition of salt on the second day is no longer necessary. Grape leaves were found to be more effective than sugar-cane leaves for the preservation of the green color. With the use of grape leaves a darker green color was produced.

ONIONS

Before fermentation it was necessary to soak the onions in fresh water, changing the water daily for two or three days. It was found that onions not soaked in water and fermented turned dark and the original color did not return even after soaking in a 3 or 4 per cent vinegar; while those that were soaked in water

before fermentation returned to their natural color after immersion in vinegar. The brine concentration safe enough for the fermentation of onions is from 50° to 60° salometer.

SUMMARY AND CONCLUSIONS

1. In general the fermented pickles were better in texture and flavor and keeping qualities than the unfermented pickles. The fermented pickles possess a characteristic, pleasing flavor due to the presence of lactic acid in the tissue of the fruit or vegetable.

2. Below 40° salometer hevi softened in texture and after softening the addition of more salt to raise the brine concentration of over 40° failed to prevent further softening of the fermented material.

3. On account of the toughness of the resulting fermented materials, eggplants, paayap, and papaya should be steamed before bottling.

4. Most of the native fruits and vegetables—namely, ampalaya, radishes, cucumbers, papaya, onions, beans, seguidillas, balimbing, cauliflower, chayote, etc.—have good pickling qualities.

5. In general most fruits and vegetables should be fermented in brine solutions of from 45° to 60°, or approximately 11 to 15 per cent salt solution.

6. The ordinary granular table salt has been found satisfactory for pickling fruits and vegetables. Better quality salt is, of course, more desirable for pickling.

7. Our studies on pickling by fermentation show that there is a bright prospect for the establishment of fermenting stations on Philippine farms to utilize surplus production of fruits and vegetables.

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TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution		Processing at 70° C.	Observation after fermentation		
				Sugar	Acetic acid		Color	Texture	Flavor
	1932	[a] *Sal*	*P. ct.*	[a] *Brix*	*P. ct.*	*Min*			
Ampalaya (sliced in big pieces)	Sept. 26	80	Neutral to litmus.	44	3.5	20	Light green...	Good.....	Good.
	Sept. 27	47							
	Sept. 28	47							
	Oct. 7	48							
	Oct. 14	49							
	Oct. 21	49							
	Oct. 28	48							
	Nov. 7	49							
	Nov. 14	50							
Balimbing (segmented)	Nov. 18	56	0.098	50	4.0	10	No discoloration.	Crisp.....	Do.
	Nov. 19	39							
	Nov. 17	42							
	Nov. 22	38							
	Nov. 22	47							
	Nov. 26	38							
	Nov. 26	53							
	Nov. 28	40							
	Nov. 28	47							
	Dec. 2	45							
	Dec. 5	44							
	Dec. 8	44							
	Dec. 14	44							
	Dec. 19	43							
Beans, string	Sept. 26	40	Neutral to litmus.	44	3.5	20	Yellowish green.	Good.....	Do.
	Sept. 27	29							
	Sept. 27	58							
	Sept. 28	49							
	Oct. 7	50							
	Oct. 14	52							
	Oct. 21	54							
	Oct. 28	53							
	Nov. 7	53							
	Nov. 14	53							

[a] Increased.

TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*—Continued

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution		Processing at 70° C.	Observation after fermentation		
				Sugar	Acetic acid		Color	Texture	Flavor
	1932	[a] *Sal*	*P. ct.*	[a] *Brex*	*P. ct.*	*Min.*			
Beans, Baguio (green)	Sept. 26	40	Neutral to litmus.	44	3.5	20	Light green...	Good.....	Good.
	Sept. 27	35							
	Sept. 27	48							
	Sept. 28	46							
	Oct. 7	46							
	Oct. 14	52							
	Oct. 21	47							
	Oct. 28	46							
	Nov. 7	47							
	Nov. 14	47							
Beans, Canadian Wonder (plus sugar-cane leaves)	Nov. 26	60	0.076	50	4.0	10	Little fading..	.....do.....	Do.
	Nov. 28	30							
	Nov. 28	51							
	Dec. 2	55							
	Dec. 8	55							
	Dec. 14	53							
	Dec. 19	53							
Beans, Canadian Wonder (blanched)	Nov. 26	52	.....	.....	.....	.....	.....	.....	.....
	Nov. 28	36							
	Nov. 28	46							
	Dec. 2	46							
	Dec. 8	46							
	Dec. 14	45							
	Dec. 13	45							
Cucumber (peeled and cut into rectangular form)	Nov. 18	56	0.021	50	4.0	10	White, translucent.	Crisp.....	Excellent.
	Nov. 19	28							
	Nov. 19	50							
	Nov. 22	40							
	Nov. 26	25							
	Nov. 26	49							
	Nov. 28	45							
	Dec. 2	45							
	Dec. 8	45							
	Dec. 14	45							
	Dec. 19	47							

Eggplant (halved and quartered. Plus grape leaves.)	Nov. 18 56 Nov. 19 38 Nov. 19 48 Nov. 22 46 Nov. 26 36 Nov. 26 55 Nov. 28 54 Dec. 2 54 Dec. 5 54 Dec. 12 52 Dec. 19 53	0.029	50	4.0	10	Faded	Tough skin	Fair.
Eggplant (halved and quartered)	Nov. 25 40 Nov. 26 28 Nov. 26 45 Nov. 28 36 Nov. 28 46 Dec. 2 45 Dec. 8 44 Dec. 14 44 Dec. 19 48	0.042	50	4.0	10	do	do	Poor.
Guava (halved)	Oct. 10 60 Oct. 14 45 Oct. 21 46 Oct. 28 45 Nov. 7 45 Nov. 14 45	0.46	44	3.5	22	Light brown	Fairly good	Good.
Guava (whole)	Oct. 10 60 Oct. 14 48 Oct. 21 48 Oct. 28 48 Nov. 7 46 Nov. 14 46	0.34	44	3.5	20	do	do	Do.
Hevi (peeled, whole)	Sept. 30 50 Oct. 7 40 Oct. 21 39 Oct. 28 38 Nov. 1 38 Nov. 7 38 Nov. 10 60 Nov. 10 [a] Nov. 14 57	0.26	(b)	(b)		do	Soft	

[a] Increased.

[b] Not packed.

TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*—Continued

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution		Processing at 70° C.	Observation after fermentation		
				Sugar	Acetic acid		Color	Texture	Flavor
	1932	[a] *Sal*	*P. ct.*	[a] *Brex*	*P. ct.*	*Min.*			
Hevi (peeled whole)	Sept. 30	50	0.42	44	3.5	20	Light brown	Fairly good	Good.
	Oct. 7	58							
	Oct. 14	59							
	Oct. 21	59							
	Oct. 28	57							
	Nov. 7	58							
	Nov. 14	58							
Hevi (peeled and sliced)	Sept. 30	50	0.49	44	3.5	20	do	Good	Do.
	Oct. 7	48							
	Oct. 14	48							
	Oct. 21	49							
	Oct. 28	50							
	Nov. 7	51							
	Nov. 14	51							
Hevi (peeled and sliced)	Sept. 30	60	0.49	44	3.5	20	do	do	Do.
	Oct. 7	50							
	Oct. 14	49							
	Oct. 21	49							
	Oct. 23	50							
	Nov. 7	50							
	Nov. 14	50							
Onion (Tagalog) (soaked in water for three days)	Dec. 16	61		50	4.0	10	Dark	do	Do.
	Dec. 17	31							
	Dec. 17	51							
	Dec. 19	49							
Paayap (plus grape leaves)	Nov. 18	56	0.059	50	4.0	10	Little discoloration.	Tough	Poor.
	Nov. 19	41							
	Nov. 26	33							
	Nov. 21	43							
	Nov. 28	45							
	Dec. 2	45							
	Dec. 10	44							
	Dec. 17	44							
	Dec. 19	44							

Papaya (peeled and cut into rectangular pieces)	Nov. 18	60	0.082	50	4.0	10	White, not translucent.	Tough. Good.
	Nov. 19	40						
	Nov. 22	41						
	Nov. 26	37						
	Nov. 26	57						
	Nov. 28	56						
	Nov. 29	55						
	Dec. 2	55						
	Dec. 5	54						
	Dec. 12	53						
	Dec. 19	51						
Pepper (green, halved)	Nov. 25	60	0.055	50	4.0	10	Faded. do.	Do.
	Nov. 26	44						
	Nov. 28	44						
	Dec. 2	45						
	Dec. 10	45						
	Dec. 17	44						
	Dec. 19	44						
Pepper (red, halved and seeds removed)	Dec. 12	54	0.132	50	4.0	10	Red. do.	
	Dec. 13	48						
	Dec. 14	52						
	Dec. 17	44						
	Dec. 19	43						
Pepper (green, halved)	Sept. 26	80	Neutral to litmus.	44	3.5	20	Light green. do.	Do.
	Sept. 27	47						
	Sept. 28	47						
	Oct. 7	48						
	Oct. 14	49						
	Oct. 21	49						
	Oct. 28	48						
	Nov. 7	49						
	Nov. 14	50						
Radish (peeled and quartered)	Sept. 26	60	0.31	44	3.5	20	White translucent.	Crisp fine. Excellent.
	Sept. 27	29						
	Sept. 28	50						
	Oct. 7	52						
	Oct. 14	53						
	Oct. 21	53						
	Oct. 28	51						
	Nov. 7	51						
	Nov 14	52						

[a] Increased.

TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*—Continued

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution		Processing at 70° C.	Observation after fermentation		
				Sugar	Acetic acid		Color	Texture	Flavor
	1932	[a] *Sal*	*P. ct.*	[a] *Brix*	*P. ct.*	*Min.*			
Radish (peeled and quartered)	Nov. 25	64							
	Nov. 26	33							
	Nov. 26	60							
	Nov. 28	48	0.076	50	4.0	10	White	Crisp	Good.
	Dec. 2	51							
	Dec. 10	51							
	Dec. 17	48							
	Dec. 19	48							
Seguidillas (plus grape leaves)	Nov. 22	60							
	Nov. 23	54							
	Nov. 26	47							
	Dec. 2	49	0.078	50	4.0	10	Dark	do	Fair.
	Dec. 10	48							
	Dec. 17	48							
	Dec. 19	48							
	Nov. 25	60							
	Nov. 28	60							
	Dec. 2	60							
	Dec. 8	60	0.029	50	4.0	10	Little discoloration.	do	Do.
	Dec. 8	44							
	Dec. 10	45							
	Dec. 14	45							
	Dec. 19	46							

[a] Increased.

TABLE 2.—*Showing results with unfermented pickles*

Kind of vegetable	Quick process							
	Date of observations	Brine solution	Composition of pickles solution		Processing at 70° C.	Observations		
			Sugar	Aceitic acid		Color	Texture	Flavor
	1932	° *Sol*	° *Brix*	*P. ct.*	*Min.*			
Cucumber	Nov. 18	56						
Do.	Nov. 23	40	50	3.5	10	White	Crisp	Good.
Eggplant	Nov. 18	56						
Do.	Nov. 22	41	44	3.5	15	Faded	Tough	Fair.
Cucumber	Nov. 25	40						
Do.	Nov. 26	25	20	4.0	15	White	Good	Good.
Seguidillas (blanched)	Nov. 25	40						
Do.	Nov. 26	37	50	3.6	10	Light green	Crisp	Do.

Kind of vegetable	Slow process							
	Date of observation	Composition of pickles solution			Processing at 70° C.	Observations		
		Sugar	Aceitic acid	Salt		Color	Texture	Flavor
	1932	° *Brix*	*P. ct.*		*Min.*			
Cucumber	Nov. 25	20	4	1 cup gallon				
Do.	Dec. 7	[a]	[a]	[a]				
Radish	Nov. 25	20	4	1 cup gallon	5	White transparent.	Soft	Fairly good.
Do.	Dec. 7	[a]	[a]	[a]	5	White	Good	Good.

ILLUSTRATIONS

Plate I

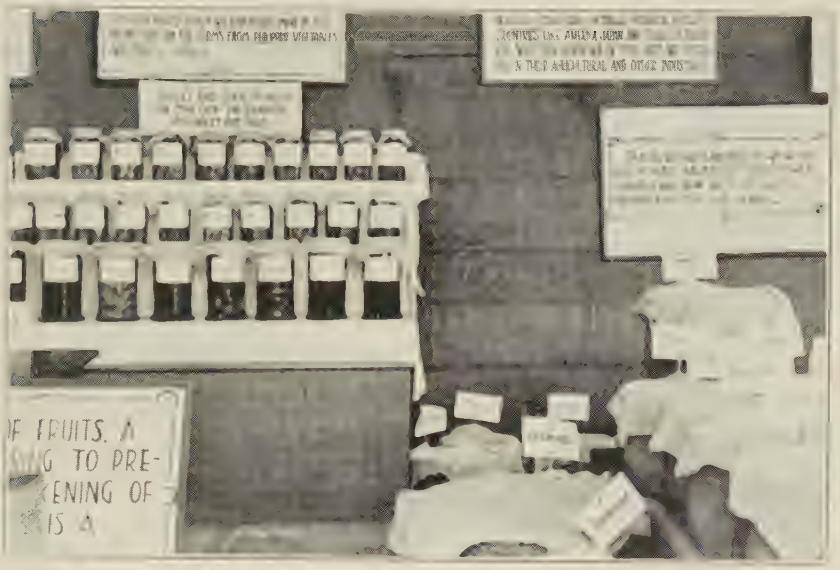
Fermentation of Philippine fruits and vegetables in barrels. A device for siphoning off the liquid and a salometer spindle are shown.

Plate II

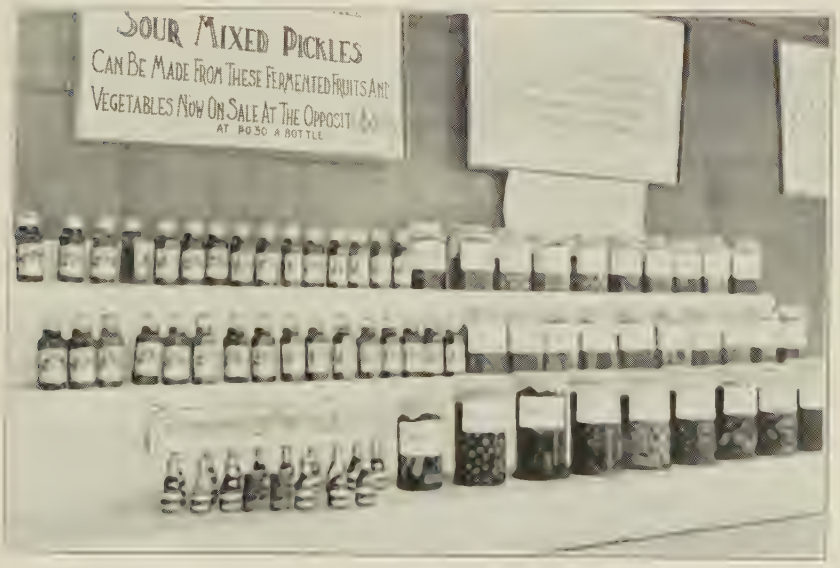
(*a*) Showing the fermented fruits and vegetables in process of preservation.

(*b*) Showing the finished products and spices and condiments used in their preparation.

PLATE 1.—Fermentation of Philippine fruits and vegetables in barrels. A device for siphoning off the liquid and a salometer spindle are shown.



(a) Showing the fermented fruits and vegetables in process of preservation.



(*b*) Showing the finished products and spices and condiments used in their preparation.

PLATE II.

STUDIES ON THE QUICK FREEZING OF PHILIPPINE FRUITS AND THE UTILIZATION OF THE FROZEN PACK PRODUCTS

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NINE PLATES

Present methods of fruit preservation may be grouped into two general classes, the first of which includes all those methods which give permanent preservation whereby the microörganisms capable of causing spoilage are killed by heat and the entrance of others prevented by the use of hermetically sealed containers, while the second takes in those methods in which conditions are made unfavorable to the growth and activity of microörganisms. Freezing and refrigeration storage belong to the second class. They give temporary but not permanent preservation.

The spoilage of food products is due to the action of certain enzymes, molds, yeast, and certain types of bacteria. The fruits and vegetables undergo biological changes which result in ripening, respiration, and other normal life processes. The microörganisms and enzymes which may work on the fruits and vegetables, as well as the ripening, respiration, and other normal processes of the fruits are most effective at certain optimum temperatures. As the temperature is lowered the enzyme action and the growth and multiplication of microörganisms are retarded, and when the drop in temperature reaches a certain limit, these activities may be entirely inhibited.

For the equable distribution of perishable foodstuffs, such as fruits, vegetables, and other food products, and for the transportation of such products to distant places, freezing storage has been practiced for more than twenty years. Apples and

other temperate fruits have been successfully kept in freezing storage for more than a year.

The refrigeration and freezing storage of temperate fruits has been the subject of numerous investigations. The extensive researches of Cruess, Diehl, Sckart, Chace, Fellers, Poore, Marsh, Birdseye, Joslyn, Overholser, Bjarnason, Taylor, Wiegand, Woodruff, and many others form the basis of present commercial practices of freezing and refrigeration storage of fruits, vegetables, meat products, fish, and other foodstuffs.

In the case of tropical fruits, however, very little work has been done along the line of preservation by freezing. In the Philippines, Higgins and Punzalan, in 1925, conducted some experiments on the refrigeration of mangoes for the purpose of determining the right temperature of storage so that these fruits might be shipped to nearby Oriental ports and possibly to America and Europe. They found that when mangoes are kept at 36°F. the fruits remained without injury for eighteen or more days but not over thirty-five days. In experiments conducted in this laboratory along the same line but using even lower temperatures and subjecting the mature but green mangoes to various treatments to delay maturity, we have found that this method of preservation for the purpose of commercial exportation is not satisfactory. After several unsuccessful attempts at delaying the maturity of mangoes, we have come to the conclusion that other methods of low-temperature treatment must be employed in order to be able to export mango and other Philippine fruits to foreign countries.

In going over the literature on freezing and refrigeration storage, we find that a good deal of work has been done on the subject in the United States by the investigators just mentioned. Therefore, it was thought that the successful results obtained by American investigators might be obtained in the freezing preservation of Philippine fruits.

When fruits are subjected to temperatures of at least 10 to 15° F., molding, fermentation, bacterial action, and the normal ripening and respiration processes are mostly, if not entirely, inhibited. The researches of Diehl have shown that by reducing the temperature of the fruits to — 40°F. as quickly as possible the growth and multiplication of spoilage organisms are temporarily retarded and the fermentation and spoilage thereby prevented. However, the darkening of the tissues, deterioration

in color, and development of an unnatural flavor will be apparent as these changes are known to occur even at the freezing temperatures owing to oxidation of certain constituents of the fruit. Oxidation has been found to be due to a large extent to the action of the enzyme oxidase, which is present in the fruit tissues and is not inhibited even at 0° F.

Researches on the freezing of plant tissues indicate that during freezing, ice forms in the tissues, generally not in the cells but in the intercellular spaces, the water moving out of the cells to form ice crystals in the spaces. As the freezing continues, the intercellular spaces between the ice and the plant tissues is filled. Injury to the texture is apparently due to the disrupture of the cell tissues and most likely to changes in the colloidal nature of the cell contents. Freezing is known to affect markedly the properties of gels and the loss in turgidity of fruit after ordinary freezing may be due to this phenomenon. The separation of water in the form of ice in and between the cells that is not absorbed produces a soft, limp, and soggy texture of the frozen fruit when it thaws.

If the temperature is very low, from –10° to –50° F., rapid freezing takes place and the entire fruit tissue freezes, resulting in the crystallization within as well as between the cells. All other conditions considered, the lower the temperature the smaller the ice crystals distributed throughout the tissues. Fruits and other food products like vegetables, meat, fish, etc., when rapidly frozen were found to be better preserved in color flavor, and texture.

It was, therefore, the object of this study to make experiments in the slow and quick freezing of some Philippine fruits which give promise of being commercially valuable for export and to determine the best methods of utilizing the frozen-pack fruits.

MATERIALS

The following Philippine and Philippine grown fruits were used in the experiments: strawberries, mangoes, avocados, lanzones, ates, guavas, young coconuts, pineapples, nangkas, lemasas, chicos, and zapotes.

Practically all these fruits were grown and harvested in the Plant Propagation Stations of the Bureau of Plant Industry. Some of them were picked when they were still green but already mature and then immediately shipped to the laboratory, where

they were allowed to ripen. As a rule fully ripe and sound fruits were used in the experiments.

Syrup.—First-class refined sugar was used in preparing syrup of different concentrations. The right amount was dissolved in water and the concentration of the syrup tested by means of a Brix hydrometer. The prepared syrup was then filtered through a double layer of muslin and then precooled in an ice box before using. Sugar solutions of from 20° to 70° Brix were prepared and used in the experiments. It was found that when fruits were frozen without syrup or by the addition of powdered refined sugar, there was much shrinkage in volume, and surface discoloration of the frozen fruits was quite apparent.

Joslyn found several advantages in the use of syrup for frozen pack fruits. Some of these are—

1. Discoloration is reduced to a minimum due to the exclusion of air from the surface of the fruit.
2. For more uniform distribution throughout the mass of the fruit syrup is more convenient to use than powdered sugar.
3. The addition of syrup rather than powdered sugar entails less damage to the fruit.
4. A more uniform and attractive pack is obtained because of less shrinkage in volume and no setting of the fruit in the container as occurs in the powdered pack.
5. Syrup can be chilled before use and therefore is a better aid to preservation.
6. The texture of the thawed fruit is better.
7. The syrup pack is applicable to all fruits.

Containers.—The following containers can be used:

No. 2 sanitary cans.
1-pint and ½-pint cartons obtained from New York.
Gallon-size slip cover tin can obtained locally.

For family use, the small size containers are satisfactory. The larger containers are better suited for export and for restaurant and hotel use.

Convenient-sized wooden boxes of barrels lined with paraffin would be good for the export trade.

IV. *Freezers and storage chambers.*—The syrup and powdered packed fruits were frozen in three ways, namely:

At 18° F., using the cold-storage chamber of the Government Ice Plant.
At 0° F., using the freezing chamber of a commercial local company.
At -20° to -40° C., using a rapid freezer, loaned by a local company.

After the fruits were frozen, they were removed to storage chambers and stored at 0°, 8°, and 18° F.

EXPERIMENTAL

STRAWBERRIES

Strawberries are shipped from our Baguio Station in specially constructed, well-ventilated shipping boxes. Using these boxes, there is less spoilage than by the former method of transporting the berries in bamboo baskets. The berries arrive in our laboratory the next day after picking. About 90 per cent of them are utilized for the frozen pack and the rest for jam and other food preparations. The strawberries are carefully sorted, stemmed and washed to remove all foreign materials and impurities. Only fully ripe, sound berries, free from decay and bruises and not too soft, are utilized for the freezing experiments, and the discarded berries are made into jams, jellies, and wine. After being washed, the berries are drained and then packed into paraffined cartons or standard sanitary No. 2 cans. As soon as the containers are filed with strawberries, a previously prepared and precooled syrup of 50 to 60 per cent is added to completely cover the fruit. Some are packed with plain sugar in the proportions of 1:1, 1:2, 1:2.5, and 1:3 in the same type of containers. This is done by adding the fruit and the sugar in alternate layers in order to obtain a uniform mixture of fruit and sugar. In the case of the cartons, the lid is put on and with the cans they are sealed by a hand-sealing machine. Then they are sent to cold storage, and frozen and stored at 18° F. the lowest available temperature at the start of our experiments. Later, however, we were able to freeze our products at 0° F. and —40° F. through the courtesy of a local firm.

MANGOES

Fully ripe mangoes free from blemishes, bruises, and decay are washed in cold water; peeled with a stainless knife and halved, quartered, and sliced. The edges are trimmed to prevent as far as possible, disintegration of the fibers. Another method of preparation is to open the fruit without peeling it and then scoop the flesh from the halved fruit with a silver spoon. Two roundish portions are removed from a half, or four from a whole fruit. Still another way is to pack it in the crushed form, by passing the peeled, pitted, and halved fruit through a meat grinder.

The halved, quartered, sliced, or scooped-out pieces of mango are then packed into cartons, No. 2 sanitary cans, or slip-cover

gallon cans. A 40 to 50 per cent syrup is added to completely cover the entire fruit, the containers are properly closed and sealed and are then ready for freezing. To the crushed mangoes 50 per cent by weight dry sugar is added, or a 1: 2 pack, filled into slip-cover gallon cans, and taken to cold storage.

Some were frozen at 18° F. and stored at the same to temperature, some at 0° F. and then after two days removed to the 18° F. room. The rest were frozen by means of solid carbon dioxide in a well-insulated quick-freezer the temperature of which ranged from —40 to —60° F. After quick freezing, which takes from three to five hours, depending on the size and type of the containers used and nature of the product, they are transferred to the 18° F. cold storage.

AVOCADOS

Well-matured, ripened avocados free from decay and bruises are peeled, pitted, and halved, quartered, or liced. Some are crushed by passing them through a meat grinder and packed with a 25 to 40 per cent dry sugar. The prepared fruits should be packed immediately, as delay in packing exposes them to oxidation and consequent discoloration. The halved, quartered or sliced fruits are packed into containers and covered with a 50 to 60 per cent syrup, and frozen at the different temperatures used for mangoes. Later, they are transferred to the 18° F. cold storage.

LANZONES

Fully ripe lanzones are washed in cold water, sorted, and opened. The segments are separated, and only seedless segments packed into containers. A syrup of 70 per cent is added to the fruit and frozen at —40° F. and stored at 18° F. Experiments on the freezing of the whole fruits without peeling them were tried by packing them in different strengths of syrup from 10 to 80 per cent.

ATES

In the case of ates, the ripe fruit is opened, the pulp scraped out with a spoon and packed direct into containers with the seeds. Another portion is packed after removing the seeds by passing the pulp through a small mesh bamboo sieve. The operator wears rubber gloves during the pulping operation. This precaution is used in other fruit preparations. Syrup ranging from 20 to 70 per cent was used, the containers are properly sealed and then the fruits are frozen.

GUAVAS

Fully ripe guavas are thoroughly washed, trimmed and halved. The seeds are scraped out with a spoon and only the pulp packed, with 70 per cent syrup. The fruits are frozen and stored at 18° F. Some were packed with seeds, all the fruit being simply cut into halves.

YOUNG COCONUTS

Young coconuts (buko) are opened, and the meat scraped out with a spoon or grated with a hand greater taking care not to include the red skin underneath. The prepared meat is packed with a 40 to 50 per cent syrup, and also with syrup made from coconut water. Freezing temperature of 18° and 0° F. were used in freezing coconuts.

MISCELLANEOUS FRUITS

Pineapples are peeled, washed, cored and sliced, and packed into containers with 50 to 60 per cent syrup. Nangkas and lemasas are opened and the seeds removed from the pulp. All adhering filaments are also removed and only the good meat is packed into containers with 60 per cent syrup and frozen at 18° F.

Ripe nangkas and lemasas are opened, and the seeds separated from the segments and washed thoroughly in cold water to remove adhering gums and other sticky matter. The cleaned pulp is packed into containers and a 60 per cent syrup added to completely cover the fruits. Then they are sent to cold storage and frozen at 18° F.

Fully ripe but not soft chicos are peeled, quartered, cored, and the seeds removed. The fruits are packed into cans and cartons with 40 per cent syrup and frozen at 0° F.

Ripe zapotes are opened and the pulp passed through a 40-mesh sieve to separate the pulp from the fiber and seeds. The prepared pulp is packed into cans and cartons with sugar in different proportions; namely, 1:1, 2:1, 2.5:1, and 3:1, and frozen at 0° F. The 2:1 pack, which means 2 parts of pulp to 1 part of sugar, was found to be best in the preparation of ice cream and sherbet.

DISCUSSION OF RESULTS

STRAWBERRIES

Strawberries preserved by freezing retained the flavor, color, and texture of the fresh fruit. The desired flavor and sweetness which is lacking in the fresh fruit is obtained by the addition

of sugar. Strawberries packed with dry sugar in the proportion 1:1 and 2:1 showed much shrinkage, and in color the frozen-pack berries are darker and the texture tougher than those packed in syrup.

Strawberries frozen at 18° F. in syrup ranging in concentration from 40 to 60 per cent are very satisfactory. Strawberries packed in 60 per cent syrup are the best. Practically no shrinkage is noticed in these samples. The color ranged from light brown to natural deep red. Surface discoloration is very slight and is apparent only in a few of the samples. Freezing of strawberries at 0° F. gave frozen-pack berries which are better in color, flavor and texture than those frozen at 18° F. Paraffined cartons are better containers than plain cans for strawberries. Plain tin cans discolor the berries, due probably to the reaction of tin on the anthocyan pigments of the berries. Strawberries are usually packed in enameled cans to prevent discoloration. In bulk, they are packed in wooden barrels or in 30-gallon enameled cans. Examination of the frozen packed berries after seven months in cold storage showed that strawberries can be successfully preserved without much change in flavor, color, and texture for a long time.

MANGOES

Experimental packs of fully ripe, firm mangoes, free from blemishes, bruises and anthracnose, showed that mangoes can be successfully preserved by freezing, with flavor, color, and texture closely approximating the fresh fruit.

Mangoes scooped out with a stainless spoon give a very fine frozen-pack product. In this form they look much like peaches. Sliced and quartered mangoes are also an appropriate form for packing, but the halved fruit is too large for small containers.

A syrup pack of 40° and 50° Brix gave a very satisfactory product. Those packed with plain sugar turn brownish and show pronounced surface discoloration. The flavor is poor, and is very different from that of the fresh fruit. Besides, considerable shrinkage and softening in texture occurs with the powdered sugar packed fruits. A 40 per cent and 50 per cent syrup packed showed little or no surface discoloration, and gave a very nice golden yellow color, especially when the fruits are totally immersed in syrup.

The various containers used in freezing mangoes were found to be very satisfactory. The color, flavor, and texture of the mangoes are in general very well preserved. For larger pack-

ages the one-gallon, slip-cover can used in packing ice cream proved satisfactory, although surface discoloration is present in many slip-cover gallon cans. The fruits should be entirely covered with syrup in order to prevent surface discoloration. Oak or other nonresinous wooden barrels lined with paraffin would be satisfactory for bulk shipment.

EFFECT OF TEMPERATURE ON FREEZING

The freezing of mangoes at 18°F. is not as satisfactory as at 0°F. and at —40°F. The mangoes frozen and stored at 18°F. are softer in texture and darker in color than the fruits frozen at lower temperatures. In one-gallon cans the fruits are not frozen hard and remain in a soft, semi-liquid form.

Freezing at 0°F. and —40°F. and storing at 18°F., the lowest available temperature in the Government cold storage plant gave products with very good color, flavor, and texture. The fruit retained the flavor of the fresh fruit. Mangoes frozen at 18°F. are of a softer texture than those frozen at 0° and —40°F. It took twenty-four hours to freeze the mangoes at 18°F., whereas only one to six hours are required when—40° and 0°F. are used as the freezing temperatures. Slow freezing is deleterious to the texture of the fruit, because of the possible destruction of the cells and tissues of the fruit by the slow formation of ice crystals between the cells. During freezing, water is withdrawn from the cells to the inter-cellular spaces where ice first forms. As freezing proceeds, these spaces become filed with ice and the cells are forced apart by the pressure of the ice crystals. With very low temperature (—40°F.), the entire fruit tissue freezes so suddenly that the ice crystals are formed within as well as between the cells.

Examination of the fruit after about eight months showed that mangoes can be preserved much longer if kept frozen and stored at the proper temperature.

Mangoes packed in the crushed form with 50 per cent syrup gave a very satisfactory product for making ice cream and sherbet. They can also be used as frozen fruit dessert, and for making pies, jam and jellies.

AVOCADOS

The preservation of avocados with the aid of heat has so far failed because an off flavor accompanied by considerable darkening of the pulp develops after cooking the fruit. This darkening or discoloration of the pulp in most fruits is due to the activation

of the enzyme oxidase naturally present in the fruit by the oxygen of the air with the formation of an organic peroxide, which in turn oxidizes the chromogen present in the fruit. This reaction seems to be almost instantaneous with avocados and for this reason considerable difficulty accompanies the preservation of this fruit by canning with the aid of heat.

Experiments on the preservation of avocados by freezing showed that the fruit can be successfully preserved in this way.

Halved, quartered, and sliced avocados frozen in 50 to 70 per cent syrup retained the flavor, color, and texture of the fruit. The different containers used in the freezing of avocados—namely, the sanitary and slip-cover cans and the cartons—were found to be satifactory. Surface discoloration is present in some of the samples. This can be greatly minimized by entirely submerging the fruits in syrup and packing them under vacuum. For this purpose, sanitary cans that can be sealed under vacuum would be the best type of containers for avocados.

EFFECT OF TEMPERATURE OF FREEZING

Avocados in syrup frozen at 0°F. and stored at 18°F. have a slight surface discoloration after three months in storage, but the color underneath is good. The flavor and texture are satisfactory. Those frozen at —40°F. and later stored at 18°F. are better in texture and flavor than those frozen at 18°F. Storage of the frozen avocados at a lower temperature, say not above 10°F., will preserve the color, flavor, and texture of the fruit better. Avocado pulp passed through a grinding machine and packed with powdered sugar in the proportion of 2:1 gave a product suitable for ice cream and sherbets. Taken alone or with cream, it makes a very nice frozen fruit dessert. The pulp should be packed immediately after crushing to prevent much darkening due to oxidation.

LANZONES

Experiments on the preservation of lanzones showed that the fruit can be successfully preserved by freezing. Only seedless segments should be packed. A 70 per cent syrup was found satisfactory for lanzones, they being acid. The different kinds of containers used in packing lanzones, namely, the sanitary and slip-cover cans, and the cartons were found to be satisfactory.

Freezing temperatures of 0° and —40°F. and storage at 18°F. were very satisfactory for lanzones. The color of the frozen

fruit is white and no surface discoloration occurs. If the cores of the segments are not removed, this part turns brown. The texture of the fruit is very good.

Experiments on the freezing of whole lanzones (in bunch), alone or with syrup, gave a product with a good color and flavor, but the skin quickly turns brown upon exposure to the air. The texture is quite soft, after the fruit is defrosted.

ATES

Ates pulp frozen with or without seeds in 20 to 60 per cent syrup in cartons and sanitary cans gave a product with a very good color, flavor, and texture. It is excellent for ice cream or when taken alone as a frozen fruit dessert. Freezing at 40°F. and storage at 18°F. gives a more satisfactory product, the fruit retaining the delicate aroma of the fresh fruit. The frozen ates can be kept in good condition for a long time. A mechanical separator that will rapidly separate the seeds from the pulp will be very desirable.

GUAVAS

Fully ripe, sliced guavas, with the seeds removed, frozen in sanitary cans and cartons in 70 per cent syrup gave a product with very good color, flavor, and texture. Freezing and storage at 18°F. is satisfactory for guavas. Frozen guava pulp is excellent for ice cream and sherbets or may be eaten as frozen fruit dessert. Guavas with seeds are also satisfactory in color, flavor, and texture.

YOUNG COCONUTS

Grated or spoon-scooped young coconuts (without including the red skin) and frozen with 40 to 50 per cent syrup made with or without any coconut water in sanitary cans or cartons gave a product that resembled coconut sherbet in flavor. The color and texture are very good. Frozen coconut can be kept for a long time at 18°F. without danger of injuring the flavor, color, and texture.

PINEAPPLES

Sliced pineapple frozen in 50 per cent syrup in sanitary and slip-cover cans and cartons at 18°F. gave a product with a very good color, texture, and flavor. The frozen fruit retained the natural fresh flavor of the pineapple, and the proteolytic enzyme present in the fresh fruit, which is destroyed in the canned fruit. Any type of container is found to be satisfactory for pineapples, although a vacuum pack would be preferable. The

texture will also be better if a lower freezing temperature is employed, say 0°F. or below.

NANGKAS AND LEMASAS

Nangka and lemasa pulp with the seeds removed, frozen at 18°F. with 50 to 60 per cent syrup, gave a product that retained the flavor, color, and texture of the fresh fruit. Any type of container was found satisfactory for nangkas and lemasas. The frozen fruit was found to be excellent after five months in cold storage at 18°F. The frozen pack fruits were found to be good for ice cream and sherbet making.

CHICOS

Sliced chicos frozen in 40 per cent syrup at 0°F. gave a product that possessed the flavor, color, and texture of the fresh fruit. Both sanitary cans and cartons are good containers for chicos. There is no surface discoloration and shrinkage in volume. The fruit is excellent as a frozen fruit dessert.

ZAPOTES

Fully ripe zapote pulp that has been passed through a 60-mesh sieve and packed with plain sugar in the proportions of 1:1, 2:1, and 3:1 showed that zapotes can be successfully preserved by freezing. Plain slip-cover gallon cans and cartons are satisfactory for zapote pulp. A freezing temperature of 0°F. is correct. The flavor of the fresh fruit is retained and is excellent for ice cream and sherbets. The 2:1 pack, which means 2 parts pulp plus 1 part sugar, is very good for ice cream. One pint of the frozen mixture to a gallon of ice-cream mix produced a delicious ice cream very nearly approximating in color and flavor chocolate ice and coffee ice cream.

THE UTILIZATION OF SOME FROZEN PACK PHILIPPINE FRUITS IN ICE CREAM MAKING

Out of the several hundred varieties of Philippine fruits, only a few have actually been used for making fruit ice creams, among which are mangoes, ates, and ube.

Ube ice cream and ube sherbet are sold the year round by all ice-cream manufacturers in Manila, other fruits being only offered to the public during the particular fruit season.

The sale of many kinds of fruit ice creams all the year round is now made possible through the preservation of the fruits during the fruiting season, either by the sterilization of the fruits

with sugar syrup in glass containers, or by freezing the fruits in syrup in tin or paraffined paper containers at temperatures ranging from 0 to 15°F.

Experience has demonstrated that sterilization of fruits with syrup tends to minimize or alter to a more or less extent the real flavor and aroma of the natural fruit, making it necessary for the ice cream manufacturers to use double and sometimes triple the amount of the sterilized fruit for flavoring the ice cream; and even then the ice cream produced is not so good as that prepared with fresh fruit.

Two methods of freezing fruits for ice cream making can be used, as follows:

a. The sorted fruit is blanched, peeled, seeds removed, transferred to the clean container and covered gradually with 40 to 60 per cent syrup to exclude the air, sealed tightly, and transferred to the chilling room.

b. The sorted fruit is blanched, peeled, seeds removed, crushed in a meat crusher and mixed with granulated white sugar in different proportions, then transferred to the clean container, sealed and chilled.

The second method has the advantage that more fruit can be stored in the minimum quantity of containers, thus taking less space in the storage room. Another advantage is that in flavoring ice cream, a less amount of the crushed fruit is necessary and less sugar and water are added to the mix, resulting in a saving of refrigerant during the process of freezing the ice cream.

The advantages of the first method are that the whole, halved or quartered fruit shows less tendency to be broken by the blades in the ice cream freezer and the finished ice cream shows large pieces of fruits. Some customers prefer to have the fruits incorporated in the ice cream in this form.

The following frozen pack Philippine fruits were found satisfactory for ice cream making:

AVOCADOS

Six to eight avocados (Cardinal variety) preserved in 60 per cent syrup are enough to flavor 10 gallons of finished ice cream. A little certified food green color can be added to enhance the appearance of the finished product. The ice cream obtained has a nice smooth body and texture with a unique taste that distinguishes it from others. This kind of ice cream is considered

delicious in American homes. Nutrition specialists have recommended it as an ideal protein food.

ATES

This fruit has a delicate illusive aroma, making it necessary to use quite a number of fruits to flavor a gallon of ice cream. Another difficulty encountered in its use is the presence of seeds, which are rather difficult to remove. A specially designed seed remover would be most welcome.

From 150 to 200 medium-sized ates are required to flavor 10 gallons of milk sherbet; and one-fourth more than the above quantity for flavoring 10 gallons of ice cream.

Some ice cream manufacturers add the whole fruit, pulp and seeds, to the ice cream mix but the resulting ice cream is troublesome to eat on account of the seeds.

CHICOS

Chico ice cream and chico sherbet are not yet popular. So far as we know, no ice cream manufacturer has given any attention to this fruit, in spite of its popularity among the Filipinos and its availability.

Chico sherbet is a good palatable dessert, preserving the delicate aroma of the fruit.

About 150 ripe regular-sized chicos, preserved in 40 per cent syrup in cold storage, are enough to flavor 10 gallons of finished sherbet. No color should be added, as the tiny pieces of the fruit look more attractive in the creamy milk sherbet.

Chicos and ates impart a slightly rough texture to the finished ice cream. This is due to their grainy pulp. In the case of ates, this defect can be avoided by carefully removing the pulp from the skin, without taking any of the meat close to the skin. Certain strains of chicos, however, have very finely grained fruit pulp.

GUAVAS

During the guava season, from July to November, a local company has succeeded in preparing guava sherbet of good quality; at one time more than 100 gallons were sold in a month.

A hundred regular-sized guava fruits (the white skin variety mixed with one-fourth of the green skin harder variety) are blanched for one minute in boiling water, and then drained quickly. They are then cut into halves, without being peeled, and the

seeds are removed completely with a curved spoon. The meat is run through a meat chopper and the pulp weighed and mixed with an equal amount of granulated white sugar.

This quantity is enough to flavor 10 gallons of milk sherbet. Some green color can be added to make it more attractive.

GUAYABANO

This fruit has more aroma and flavor than ates or anonas. Its sour taste make it ideal for salad purposes, but not so good for ice cream making; although several people have shown a liking for guayabano sherbet.

The guayabano is specially adapted for water ices, and a good-sized fruit is enough to flavor 1 gallon of guayabano water ice. In making this frozen product it is unnecessary to add citric acid, as the guayabano is sour enough to impart the characteristic acid taste required in fruit ices.

JACK FRUIT (NANGKA)

A good-sized nangka should give from 1.5 to 2 kilos of fruit meat. This meat is either preserved in 60 per cent syrup and placed at once in a 5°F. room or pulped in a meat shopper and then mixed with sugar in the proportion of 2 parts fruit to 1 part sugar.

From 4 to 6 kilos of the edible meat or its equivalent in the preserved state is necessary to flavor 10 gallons of sherbet. Unlike mango, nangka sherbet preserves the original flavor and aroma after several months of storage.

MANGO

This fruit makes wonderful sherbet and water ice, and is also satisfactory for ice cream making.

From 18 to 24 good-sized ripe mangoes are enough to flavor 10 gallons of milk sherbet, or 7 gallons of water ice. A bit of yellow certified food color improves the appearance of the finished product.

In the utilization of mangoes, either fresh or frozen, for the manufacture of frozen desserts, these should be made and eaten fresh because it has been found that mango sherbet or mango water ice kept at freezing temperature for periods longer than five days develop a decided turpentine taste, which although not repulsive is quite different from the original fresh mango flavor.

UBE

Ube, because of its characteristic and mild taste, is largely used for ice cream making. Ubes are first cooked, preferably in a pressure cooker, at 5 pounds pressure for one-half to one hour, depending upon the amount of tuber being cooked. The cover of the cooker should not be removed until the temperature has returned to normal in order not to lose any of the aroma of the tuber.

The cooked tuber is then peeled, cut into small pieces, run through a meat chopper and mixed with one-third its weight of sugar, transferred into tin containers and chilled at 5°F.

From 6 to 8 kilos of ube or its equivalent of the preserved tuber are sufficient to flavor 10 gallons of ice cream or sherbet. A tinge of purple color is added to the finished product.

ZAPOTE

This plant, which hitherto has had no commercial value, grows well in many places of the Philippines. It bears many fruits of high food value. The fruit pulp, after the seeds have been removed, is mixed with one-third its weight of sugar, and preserved at 5°F.

From fifteen to twenty fruits or their equivalent of preserved pulp is required to flavor and color 10 gallons of finished sherbet.

The zapote has a rich coffee brown color and a smooth texture. The flavor is similar to chico sherbet.

LANZONES

This fruit does not blend well in either ice cream or milk sherbet, but makes very good water ice. Two hundred large lanzones or 400 small or medium-sized fruits are enough to flavor 7 gallons of finished fruit ice.

It is necessary to reject the segment or segments having large seeds, as otherwise a bitter taste will be imparted to the finished product. The selected segments are crushed gently before mixing them with the water-ice base.

SUMMARY AND CONCLUSIONS

1. Various Philippine fruits, namely: strawberries, mangoes, avocados, lanzones, ates, guavas, young coconuts, pineapples, nangkas, lemasas, chicos, and zapotes have been successfully preserved by freezing at 18°F., 0°, and —40°F.

2. In most of the frozen pack fruits studied the natural flavor of the fresh fruits had been retained or improved with very

good preservation of the original color and texture after defrosting.

3. Freezing at 0°F. and —40°F. gave frozen pack products possessing better flavor, color and texture than those frozen at 18°F. This is especially more pronounced in the case of mangoes and avocados.

4. Air-tight containers are preferable to the friction or slip-cover cans or cartons, but the latter are also satisfactory.

5. Surface discoloration is apparent in many of the samples examined. This may be prevented by complete immersion in syrup, and could be entirely eliminated by vacuumizing the containers before closing.

6. A syrup pack of from 40° to 60° Brix is very satisfactory depending upon the nature of the fruits packed. Syrup pack has many advantages over the dry sugar pack method.

7. The principal justification for freezing as a means of preserving fruits lies in the better preservation of color, flavor and texture. Seasonal fruits can thereby be made available throughout the year. Frozen pack Philippine fruits open up a promising export industry.

8. Frozen fruits have varied uses. They are excellent for ice cream and sherbet making. Avocado and zapote ice creams prepared from the frozen fruit pulp are pronounced excellent. When taken alone, frozen pack fruits may be used as a frozen fruit dessert. They are also useful for salads, pie and cake fillers, and can easily be made into jams, jellies and preserved and crystallized fruits.

9. Methods of commercially utilizing frozen pack Philippine fruits have also been discussed.

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TABLE 1.—*Experiments on the preservation of Baguio strawberries by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Feb. 19	Sorted, hulled, washed, drained, and packed with refined cane sugar in the proportion of 1.1.	.....	Sanitary can No. 2	5	18	18	0.5
Feb. 19	Sorted, hulled, washed, drained and packed with sugar in the proportion of 2.1	.....	Nestrite carton	4	18	18	0.5
Mar. 1	Sorted, hulled, washed, drained and packed with syrup	40	Sanitary can No. 2	10	18	18	0.5
Mar. 4	do	40	Nestrite carton	12	18	18	1
Mar. 4	do	50	do	6	18	18	1
Mar. 4	do	60	do	6	18	18	1
Mar. 11	do	40	do	7	18	18	2
Mar. 11	do	50	Sanitary can No. 2	8	18	18	2
Mar. 11	do	60	do	10	18	18	2
Mar. 17	do	60	do	15	18	18	3
Mar. 18	do	60	Nestrite carton	16	0	18	4
Mar. 21	do	60	do	21	0	18	5
Mar. 29	do	60	do	13	0	18	5
April 12	do	60	do	12	0	18	6
April 19	do	60	do	14	0	18	7

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Feb. 19	Sorted, hulled, washed, drained and packed with sugar in the proportion of 1:1.	Slight	Brownish	Fair, over sweet	Much shrinkage; soft	Poor.
Feb. 19	Sorted, hulled, washed, drained and packed with sugar in the proportion of 2:1.	do	Good	Good	Little shrinkage; fair	Good.
Mar. 1	Sorted, hulled, washed, drained and packed with syrup.	None	Slightly dull red	Very good	No shrinkage; slightly soft	Do.
Mar. 4	do	do	Natural deep red	Natural but tart	do	Do.
Mar. 4	do	do	do	Very good	No shrinkage and disintegration.	Very good.
Mar. 4	do	do	Very good	Excellent	Good	Excellent.
Mar. 11	do	Slight	do	Somewhat tart	No shrinkage; slightly soft	Good.
Mar. 11	do	None	Dull brown	Excellent	do	Very good.
Mar. 11	do	do	do	do	do	Do.
Mar. 17	do	do	do	Very good	No shrinkage; texture good	Good.

Mar. 18	....do....	....do....	Natural deep red....	Excellent....	No shrinkage and disintegration; firm texture.	Excellent.
Mar. 21	....do....	Slight....	....do....	Very good....	....do....	Very good.
Mar. 29	....do....	None....	....do....	Excellent....	....do....	Excellent.
April 12	....do....	Slight....	Dark red....	Very good....	....do....	Very good.
April 19	....do....	....do....	....do....	....do....	No shrinkage; slightly soft...	Good.

TABLE 2.—*Experiments on the preservations of mangoes by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Mar. 11	Washed, pealed, pitted, and sliced; packed with sugar in the proportion of 2:1	....	Nestrite carton....	6	18	18	1.5
April 4	Washed, peeled, pitted, and sliced	40	....do....	13	18	18	30
April 4	....do....	50	....do....	8	18	18	30
April 5	Washed, peeled, pitted, and cubed	40	Sanitary can No. 2....	10	18	18	2
April 5	Washed, peeled, and halved	50	.... do....	10	18	18	2
April 13	....do....	50	Nestrite carton....	10	0	18	2.5
April 14	Washed, peeled, halved, and cubed	50	....do....	5	40	18	2
April 19	Washed, peeled, halved, and quartered	50	....do....	28	40	18	4
April 27	Washed, peeled, pitted, and sliced	40	....do....	15	0	18	3
April 27	....do....	50	....do....	12	0	18	3
April 29	....do....	40	....do....	10	0	18	5
May 3	Washed, peeled, pitted, and quartered	50	....do....	39	0	18	4
May 4	Washed, peeled, and halved	50	Slip-cover gallon can...	19	0	18	4
May 20	Washed, peeled, pitted, and sliced	50	Nestrite carton....	12	0	18	4
May 27	Washed, peeled, pitted, and quartered	50	Slip-cover gallon can...	2	18	18	3
May 28	....do....	50	Nestrite carton....	28	18	18	4
May 31	Washed, peeled, halved and crushed plus 50 per cent sugar	....	Slip-cover gallon can...	9	0	18	4
June 7	Washed, halved, and scooped out with stainless spoon	40	....do....	9	0	18	6
June 9	....do....	40	Sanitary can No. 2....	23	40	18	6
June 9	....do....	50	Nestrite carton....	20	40	18	6

TABLE 2.—*Experiments on the preservations of mangoes by freezing*—Continued

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Mar. 11	Washed, peeled, pitted, and sliced; packed with sugar in the proportion of 2:1.	Much	Dark brown	Poor	Very soft; considerable shrinkage.	Poor.
April 4	Washed, peeled, pitted, and sliced	Slight	Brownish yellow	Good	No disintegration; some shrinkage.	Fair.
April 4	do	None	Golden yellow	Very good	No shrinkage; texture firm	Good.
April 5	Washed, peeled, pitted, and cubed	do	do	Good	do	Do.
April 5	Washed, peeled, and halved	do	do	do	No shrinkage; slightly soft	Fair.
April 15	do	Slight	Brownish	Fair	Slightly shrinkage; slightly soft.	Do.
April 19	Washed, peeled, halved, and cubed	None	Golden yellow	Excellent	No shrinkage; firm	Excellent.
April 19	Washed, peeled, halved, and quartered	do	do	do	No shrinkage, no disintegration very good texture.	Do.
April 27	Washed, peeled, pitted, and sliced	do	do	Very good	do	Do.
April 27	do	do	do	Excellent	do	Do.
April 19	do	do	do	Very good	do	Very good.
May 3	Washed, peeled, pitted, and quartered	do	do	do	do	Do.
May 4	Washed, peeled, and halved	Slight	Brownish	Good	Slight shrinkage. Slightly soft.	Fair.
May 20	Washed, peeled, pitted, and sliced	None	Golden yellow	Very good	No shrinkage; firm	Very good.
May 27	Washed, peeled, pitted, and quartered	Much	Brownish yellow	Poor	Much disintegration and shrinkage; poor texture	Poor.
May 28	do	None	Golden yellow	Good	No shrinkage; good texture	Good.
May 31	Washed, peeled, halved, and crushed plus 50 per cent sugar.	Much	Dark brown	Fair	Slight shrinkage; texture soft	Fair.
June 7	Washed, halved, and scooped out with stainless spoon.	Slight	Golden yellow	Excellent	No shrinkage; texture good	Excellent.
June 9	do	None	do	do	No shrinkage; very good	Do.
June 9	do	Very slight	do	do	do	Good.

TABLE 3.—*Experiments on the preservation of avocados by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
May 26	Washed, peeled, pitted, and halved	40	Sanitary can No. 2	8	0	18	1
June 9	Washed, peeled, pitted, and sliced	50	do	6	0	18	
June 9	do	50	Nestrite carton	6	0	18	1
July 21	do	40	do	7	0	18	1
July 22	do	60	Sanitary can No. 2	5	0	18	1
July 23	Washed, peeled, pitted, and halved	60	do	19	0	18	2
July 25	Washed, peeled, pitted, and sliced	60	Slip-cover gallon can	9	0	18	3
Aug. 1	Washed, peeled, pitted, and quartered	60	do	8	0	18	1
Aug. 2	do	60	do	17	0	18	2
Aug. 3	do	70	do	8	0	18	3
Aug. 4	do	70	Nestrite carton	19	0	18	2
Aug. 5	do	60	Slip-cover gallon can	9	0	18	2
Aug. 6	do	60	Nestrite carton	8	40	18	3
Aug. 8	Washed, peeled, pitted and crushed in a meat grinder; packed with sugar in proportion 1:1.	60	Sanitary can No. 2	11	40	18	3
Aug. 9	Washed, peeled, pitted, and crushed in a meat grinder; packed with sugar in proportion 2:1.	Slip co.	Slip-cover gallon can	5	0	18	3
Aug. 10	Washed, peeled, pitted and crushed in a meat grinder; packed with sugar in the proportion of 3:1.	.....	Nestrite carton	13	0	18	3
		.....	Sanitary can No. 2	5	0	18	3

TABLE 3.—*Experiments on the preservation of avocados by freezing*—Continued

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
May 26	Washed, peeled, pitted, and halved	Slight	Dark green	Fair	Some disintegration; texture slightly soft.	Fair.
June 9	Washed, peeled, pitted, and sliced	do	Olive green	Good	Some disintegration; texture fair.	Good.
June 9	do	Much	Dark green	Poor, somewhat stale	Much shrinkage; soft	Poor.
June 16	do	do	Dull green	Poor, overipe	do	Do.
July 21	do	None	Bright green	Good	Little shrinkage; good texture.	Good.
July 22	do	do	do	Excellent	No shrinkage; texture good	Excellent.
July 23	Washed, peeled, pitted, and halved	Slight	Dull green	Good	Slight disintegration texture	Good.
July 25	Washed, peeled, pitted, and sliced	None	do	Very good	No disintegration; good texture.	Very good.
Aug. 1	Washed, peeled, pitted, and quartered	do	do	Good	do	Do.
Aug. 2	do	do	do	Fair, oversweet	Incompletely frozen syrup; too tick texture soft.	Poor.
Aug. 3	do	Slight	do	Over sweet	Slight disintegration; texture fair.	Fair.
Aug. 4	do	None	Bright green	Good	No disintegration texture; good.	Good.
Aug. 5	do	do	do	Very good	do	Excellent.
Aug. 6	do	do	do	Excellent	Very good	Do.
Aug. 8	Washed, peeled, pitted and crushed in a meat grinder; packed with sugar in proportion 1:1.	Slight	Dark green	Fair, too sweet	Some shrinkage; quite soft	Poor.
Aug. 9	Washed, peeled, pitted, and crushed in a meat grinder; packed with sugar in proportion 2:1.	do	Dull green	Good	No shrinkage; good texture	Good.
Aug. 10	Washed, peeled, pitted, and crushed in a meat grinder; packed with sugar in proportion of 3:1.	None	do	do	No shrinkage; good	Do.

TABLE 4.—*Experiments on the preservation of lanzones by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Aug. 30	Peeled, segmented, sorted, and packed with syrup	60	Nestrite carton	7	0	18	15
Aug. 30	Peeled, segmented, sorted, and packed with syrup; core at center removed	60	Sanitary can No. 2	6	0	18	15
Sept. 21	Washed, and packed without peeling the fruit and frozen		do	2	—40	18	18
Sept. 21	Washed and packed in syrup with peeling	70	Nestrite carton	2	—40	18	18
Sept. 21	do	80	do	2	—40	18	18
Sept. 21	Washed, peeled, and all segments packed in syrup	70	do	4	—40	18	18
Sept. 21	do	80	do	2	—40	18	18
Sept. 21	Washed, peeled, segmented, and sorted; only seedless segments packed in syrup	70	do	10	—40	18	30
Oct. 3	Washed and packed whole with peeling in syrup	60	Slip-cover gallon can	2	0	0	30
Oct. 3	do	50	do	2	0	0	30
Oct. 3	do	40	do	2	0	0	30
Oct. 4	Washed, peeled, segmented, and sorted; seedless segments cut through the seed to detect presence of small seeds; the cut portions packed in syrup.	70	Sanitary can No. 2	12	—40	18	60

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TABLE 4.—*Experiments on the preservation of lanzones by freezing*—Continued

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Aug. 30	Peeled, segmented, sorted, and packed with syrup.	Slight	Brown at the core	Poor; bitter	No shrinkage, slight disintegration; good texture.	Poor.
Aug. 30	Peeled, segmented, sorted, and packed with syrup; core at center removed.	None	Good	Poor; slightly bitter	do	Fair.
Sept. 21	Washed, and packed without peeling the fruit and frozen.	Much	Brown skin; pulp white.	Insipid	Soft	Very poor.
Sept. 21	Washed and packed in syrup with peeling	Slight	Good	Good	No shrinkage; slightly soft	Good.
Sept. 21	do	None	do	Oversweet	Slight shriveling; soft after thawing.	Poor.
Sept. 21	Washed, peeled, and all segments packed in syrup.	do	do	Poor; bitter	No shrinkage; texture good	do
Sept. 21	do	do	do	Poor; slightly bitter	do	do
Sept. 21	Washed, peeled, segmented, and sorted; only seedless segments packed in syrup.	do	Very good	Good	do	Very good.
Oct. 3	Washed, and packed whole with peeling in syrup.	Much	Brownish	Poor; flat	Slight shrinkage; slightly soft.	Poor.
Oct. 3	do	do	do	do	do	do
Oct. 3	do	Slight	do	Poor; acid	Very soft	Very poor.
Oct. 4	Washed, peeled, segmented, and sorted; seedless segments cut through the seed to detect presence of small seeds; the cut portions packed in syrup.	None	Good	Excellent	No shrinkage; good	Excellent.

TABLE 5.—*Experiments on the preservation of ates by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
July 13	Opened, scraped with a spoon, and packed with the seeds in syrup	70	Sanitary can No. 2	4	—40	18	0.5
Aug. 6	do	60	do	4	—40	18	1
Sept. 24	Opened, scraped with a spoon, and the seeds removed by sieving, and the pulp packed in syrup.	10	Nestrite carton	9	—40	18	1
Sept. 26	do	20	Sanitary can No. 2	6	—40	18	1
Sept. 27	do	20	do	8	—40	18	2
Sept. 28	do	20	Nestrite carton	12	—40	18	2

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discolcrati n	Color	Flavor	Size and texture of fruit	
1932						
July 13	Opened, scraped with a spoon, and packed with the seeds in syrup.	None	Very good	Good; oversweet	No shrinkage; good	Very good.
Aug. 6	do	do	do	Excellent	do	Excellent.
Sept. 24	Opened, scraped with a spoon, and the seed removed by sieving, and the pulp packed in syrup.	do	Slightly darker	Natural; somewhat flat	No shrinkage	Good.
Sept. 26	do	do	Good	Natural; good	do	Very good.
Sept. 27	do	do	do	Very good	do	Very poor.
Sept. 28	do	do	Very good	do	do	Excellent.

TABLE 6.—*Experiments on the preservation of guavas by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Aug. 9	Washed, peeled, and halved	70	Nestrite carton	10	18	18	2
Aug. 21	Washed, peeled, halved, and the seeds removed with a spoon	70	Ditto	18	18	18	2
Aug. 11	do	70	Sanitary can No. 2	12	18	18	3

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Aug. 9	Washed, peeled, and halved	None	Very good	Good	No shrinkage; good	Good.
Aug. 1	Washed, peeled, halved, and the seeds removed with a spoon.	do	do	Excellent	do	Excellent.
Aug. 11	do	do	do	do	do	do

TABLE 7.—*Experiments on the preservation of young coconuts (buko) by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
July 6	White meat grated and packed in plain syrup	40	Sanitary can No. 2	10	0	18	2
July 8	White meat scraped with spoon and packed in plain syrup	40	do	12	0	18	2
Aug. 11	do	50	do	8	0	18	3
July 12	White meat scraped with spoon and packed in syrup made of coconut water	50	do	10	0	18	2
July 14	do	50	Nestrite carton	9	0	18	2

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
July 6	White meat grated and packed in plain syrup.	None	Good	Very good	No shrinkage; good	Excellent.
July 8	White meat scraped with a spoon and in plain syrup.	do	do	do	do	do.
July 11	do	do	do	do	do	do.
July 7	White meat scraped with spoon and packed in syrup made of coconut water.	do	do	Natural; excellent	do	do.
July 14	do	do	Very good	do	do	do.

TABLE 8.—*Experiments on the preservation of miscellaneous fruits by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Apr. 22	Pineapple; peeled, cored, and sliced	50	Sanitary can No. 2	10	18	18	5
June 16	do	60	Slip-cover gallon can	4	18	18	6
Apr. 30	Nangka; pulp washed and seeds removed	60	do	6	18	18	5
May 12	Lemasa; pulp washed and seeds removed	60	do	15	0	18	5

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Apr. 22	Pineapple; peeled cored, and sliced	None	Very good	Natural; excellent	No shrinkage; good	Excellent.
June 16	do	Slight	Good	do	do	Good.
Apr. 30	Nangka; pulp washed and seeds removed	do	do	Natural; good	Good; little tough	do.
May 12	Lemasa; pulp washed and seeds removed	do	do	do	No shrinkage; good	do.

ILLUSTRATIONS

Plate I

Left to right: Mangoes and pineapples in gallon cans; ates, lanzones and avocados in No. 2 sanitary cans; avocados, zapotes and mangoes in Nestrite cartons.

Plate II

(*a*) Left to right: Sliced pineapple and sliced mango removed from containers.

(*b*) Left to right: Sliced mango frozen in gallon can, zapote pulp, cubed mango, sliced avocado in Nestrite cartons, and sliced pineapple in gallon can.

Plate III

(*a*) Left to right: (1) Pineapple and mango frozen in gallon cans; lanzones, mango and ates pulp in Nestrite cartons. (2) Pineapple and mango frozen in gallon cans; lanzones, mango and ates pulp in Nestrite cartons.

(*b*) Front picture; left to right: Mango, papaya, ates, avocado. Back picture; left to right: Pineapple, mango.

Plate IV

(*a*) Guayabano fruit.

(*b*) Nangka fruit (½ fruit).

Plate V

(*a*) Chico fruit.

(*b*) Zapote fruit.

Plate VI

(*a*) Nangka fruits.

(*b*) Coconuts.

Plate VII

(*a*) Lanzones.

(*b*) Guava fruit.

Plate VIII

(*a*) Mangoes.

(*b*) Avocados.

Plate IX

(*a*) Smooth Cayenne pineapple.

(*b*) Especially constructed crate for transporting strawberries.

PLATE 1.—Left to right; mangoes and pineapples in gallon cans; ates, lanzones and avocados in No. 2 sanitary cans; avocados, zapotes and mangoes in Nestrite cartons.

(*a*) Left to right: Sliced pineapple and sliced mango removed from containers.

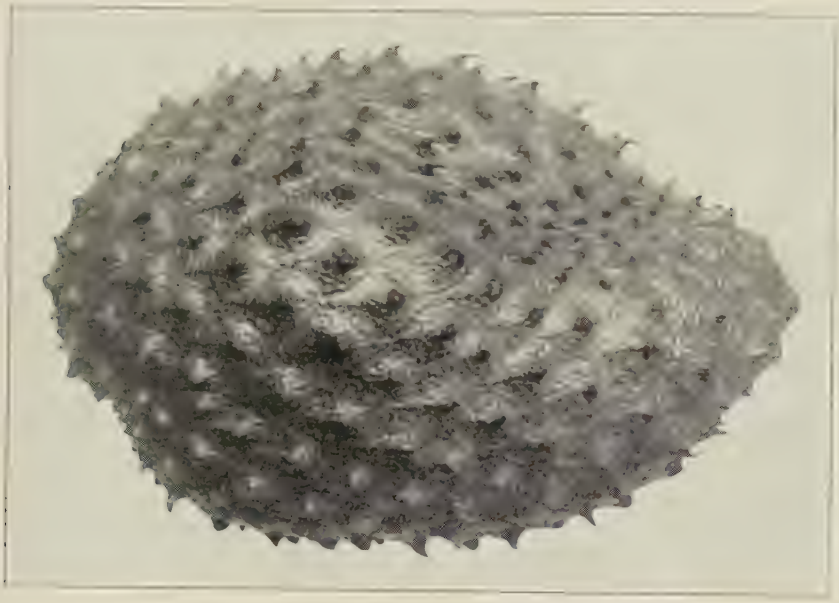
(*b*) Left to right: Sliced mango frozen in gallon can, zapote pulp, cubed mango, sliced avocado in Nestrite cartons, and sliced pineapple in gallon can.

PLATE II.

(*a*) Left to right: (1) Pineapple and mango frozen in gallon cans; lanzones, mango and ates pulp in Nestrite cartons. (2) Pineapple and mango frozen in gallon cans; lanzones, mango and ates pulp in Nestrite cartons.

(*b*) Front picture; left to right: Mango, papaya, ates, avocado. Back picture; left to right: Pineapple, mango.

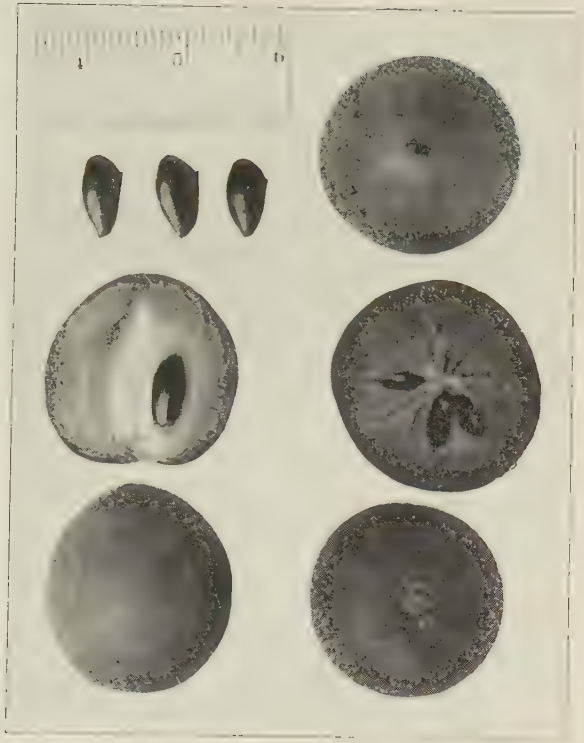
PLATE III.



(*a*) Guayabano fruit.

(*b*) Nangka fruit (½ fruit).

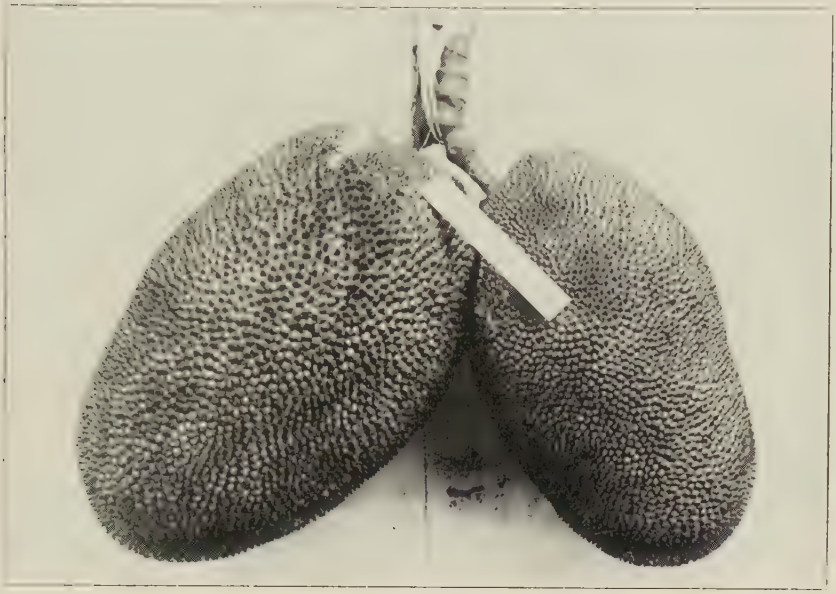
PLATE IV.



(*a*) Chico fruit.

(*b*) Zapote fruit.

PLATE V.



(*a*) Nangka fruits.

(*b*) Coconuts.

PLATE VI.

(*a*) Lanzones.

(*b*) Guava fruit.

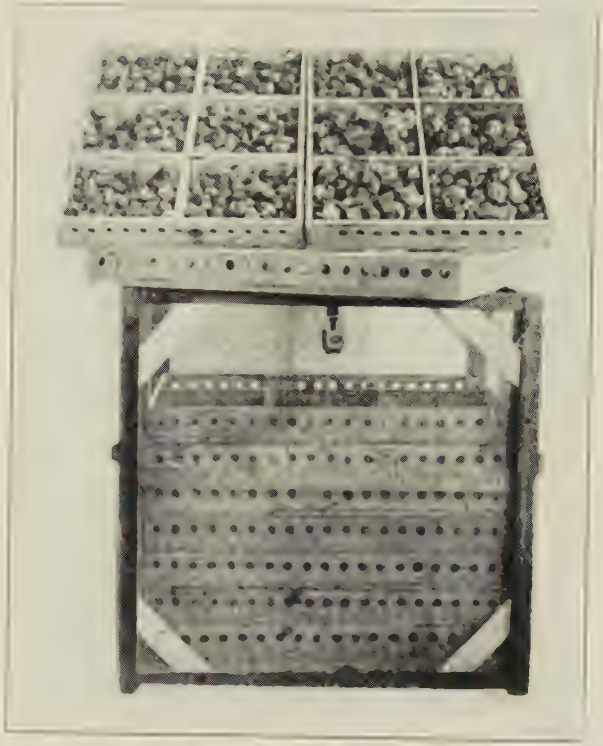
PLATE VII.

(*a*) Mangoes.

(*b*) Avocados.

PLATE VIII.

(*a*) Smooth Cayenne pineapple.



(*b*) Especially constructed crate for transporting strawberries.

PLATE IX.

THE EFFECT OF FERTILIZERS AND GRASS MULCH ON THE STRAWBERRY FIELD

By Pedro A. Rodrigo

Of the Bureau of Plant Industry, Manila

THREE TEXT FIGURES

With the growing popularity of the strawberry (*Fragaria chiloensis*), in certain regions in the Philippine Islands, more information about its culture under local conditions will be in demand. Primarily in anticipation of this need, the experiment reported in this paper was undertaken. The work, which was done at the Baguio Semitemperate Fruit Station of the Bureau of Plant Industry, was started in July, 1931, and completed in June, 1932.

REVIEW OF LITERATURE

The common belief among strawberry growers in Baguio and in Trinidad Valley is that it does not pay to fertilize strawberries. It is their usual experience that strawberries when fertilized have an excellent vegetative growth but a poor yield. An investigation of the matter, however, disclosed the fact that the fertilizer they used almost exclusively was ammonium sulphate, the one commonly used for cabbages in the region. Such a fertilizer, while it gives good results when applied to cabbages, does not favor production of strawberries because it furnishes nitrogen only.

Rodrigo and Dirige [1] reported that a coöperator of the Bureau of Plant Industry in Trinidad Valley, Mountain Province, obtained less income from a fertilized strawberry field than from an unfertilized one of the same area. In strawberry culture in the United States, fertilizers are applied to suit the needs of the soil. Darrow [2] suggests the application of 100 to 700 pounds of phosphoric acid, 50 to 300 pounds of potash, and 50 to 200 pounds of nitrogen to one acre of strawberries.

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[1] Rodrigo, P. A., and M. Dirige, Strawberry Culture, Philip. Journ. Agr. 2 (1931) 3–13 + 4 pls.

[2] Darrow, G. M., Strawberry Culture: Eastern United States, U. S. Dept. Agr. Farmers' Bull. No. 1028 (1923).

Mulching is one of the essentials of successful strawberry culture in the United States,[3] pine needles, and straw of various kinds being commonly used for this purpose. Mulching in the United States serves to keep the fruits clean, to conserve moisture, to keep down weeds, and to prevent the soil from baking. In the Trinidad Valley, Mountain Province, the use of straw mulch in strawberry culture is not yet understood or practiced.

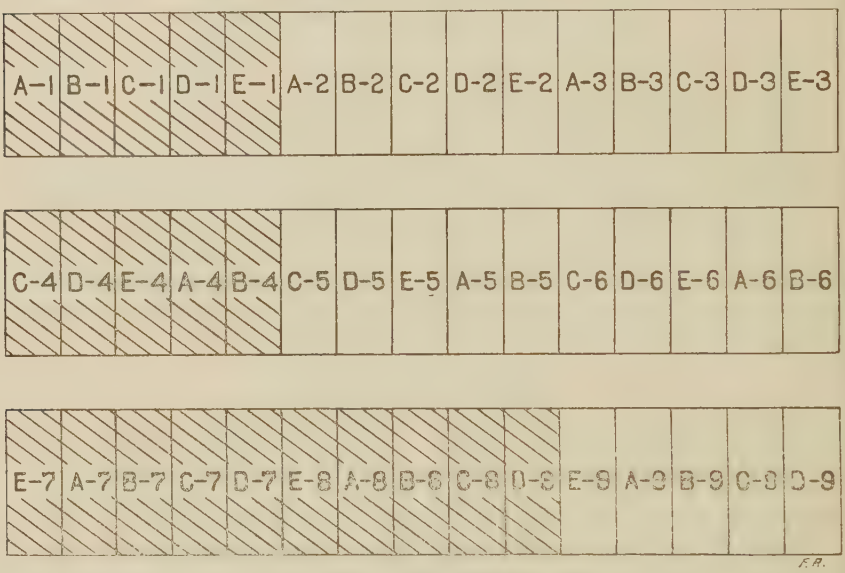

FIG 1. Graph showing the arrangement of the experimental plots. Plot A served as check; Plot B, fertilized with stable manure at 20 tons per hectare; Plots C, D, and E fertilized with a 5–10–5 commercial fertilizer at 200, 500, and 800 kilos per hectare, respectively. The shaded plots were not mulched; the rest were mulched with dry grass and pine needles.

MATERIALS AND METHODS

The field devoted to this experiment was level and fairly uniform in fertility except one corner where the surface soil had been removed when the ground was leveled. An excellent crop of soybeans was plowed under before the field was prepared for the experiment. Plots 25 square meters in area (3 by 8.34 m) were laid out, and prepared for planting as uniformly as could possibly be done.

Stable manure, and a complete fertilizer (5–10–5) applied in different amounts, were incorporated in the soil as shown in fig. 1. The fertilizer used was compounded in the station. It contained 5 per cent nitrogen, 10 per cent phosphorus, and 5

[3] Moore, J. G., Strawberry Culture in Wisconsin, Wis. Agr. Exp. Sta. Bull. No. 360 (1929).

per cent potash. Ammonium sulphate supplied the nitrogen in this fertilizer, double superphosphate furnished the phosphorus, and sulphate of potash was the source of the potassium. The stable manure was applied at the rate of 20 tons per hectare, and the other fertilizer at the rate of 200, 500, and 800 kilos per hectare. The stable manure was applied and incorporated in the soil about a week before planting. One-half of the commercial fertilizer in each treatment was applied just before planting, and the other half September 24, 1931, when the plants had recovered from the effect of transplanting. Each treatment was replicated nine times, including that for the check plots. The methods of laying off the experiment plots is shown in fig. 1.

The variety Hood River was used in this experiment. The runners were prepared for planting by pruning the roots and cutting off the leaves, except a few of the young ones. The entire field was planted in two days. The plants were set 25 cm apart in rows spaced 50 cm apart.

Early in November, 1931, plots A–2, A–3, A–5, A–6, A–9, B–2, B–3, B–5, B–6, B–9, C–2, C–3, C–5, C–6, C–9, D–2, D–3, D–5, D–6, D–9, E–2, E–3, E–6, and E–9 were mulched with dry pine needles and dry grass as indicated in fig. 1. The mulch, which was about 5 cm thick, was spread after a thorough cultivation and weeding had been done. Plots A–1, A–4, A–7, A–8, B–1, B–4, B–7, B–8, C–1, C–4, C–7, C–8, D–1, D–4, D–7, D–8, E–1, E–4, E–7, and E–8 were also cultivated and weeded but were left without any grass mulch. Fig. 1 further shows the arrangements of the mulched and the unmulched plots.

The mulched plots were weeded twice during the whole progress of the experiment, while the unmulched plots were cultivated and weeded nine times. Both mulched and unmulched plots were irrigated more or less the same. The first harvest was gathered November 24, 1931; and harvesting continued until the second week of June, 1932. The picking was done at 1- to 3-day intervals. The fruits from each plot were put in a paper bag, labeled accordingly, and then weighed and recorded.

Field observations were made of the general growth of the plants, the general quality of the berries in the field, and on the prevalence of diseases attacking the leaves and fruits under the different treatments.

EXPERIMENTS AND RESULTS

This experiment was run with two main objects; namely, to determine the effect of different amounts of commercial ferti-

lizers on the productions of strawberry, and the effect of mulch on the yield and the quality of the berries. To get data on the second point half of the fertilizer plots were mulched, and the other half left unmulched.

The data reported in this paper were obtained during the strawberry season of 1931–1932.

Field observations.—It was observed that the plants in the fertilized plots had a tendency to recover earlier from the effect of transplanting. When the plants were fully recovered, there was virtually no effect from the fertilizers on the general stand of the crop. Even when the plants were in full bearing, the different in stand was, at best, slightly in favor of the plots heavily treated with commercial fertilizers; the plants in the fertilized plots were darker green in color. On the other hand, plants that were mulched, whether fertilized or not, were decidedly bigger than the unmulched plants.

Ripening berries were attacked by certain kinds of fruit rot. This was especially true during warm moist days. The proportion of infected berries was markedly greater in the unmulched plots. Berries gathered from the mulched plots were decidedly clearner than those from the unmulched plots. The berries in the mulched plots were absolutely clean even just after a rain, or the application of irrigation water.

Tables 1, 2, 3, and 4 present the summarized results of the experiments. Table 1 gives the 15-day average yields of the different treatments, thus presenting in a graphic way the march in yield throughout the bearing period of the plants. Table 2 shows the effect of some fertilizers on strawberry production.

TABLE 1.—*Showing the average 15-day yield of strawberry as affected by mulch and commercial fertilizers*

Fertilizers applied	Mulched	Yield every 15-day period						
		Nov. 24–Dec. 8	Dec. 9–23	Dec. 24–Jan. 7	Jan. 8–22	Jan. 23–Feb. 6	Feb. 7–21	Feb. 27–Mar.
Check	No.	0.58	0.51	0.51	0.71	1.51	1.35	1.41
Stable manure at 20 tons per ha	No.	0.72	0.63	0.85	1.04	1.91	2.08	2.20
Commercial fertilizer at 200 kg	No.	1.15	0.82	0.80	1.17	1.70	1.80	1.84
Commercial fertilizer (5–10–5) at:								
500 kg per ha	No.	1.09	0.70	1.01	1.08	1.93	1.84	1.78
800 kg per ha	No.	1.46	1.18	1.49	1.60	2.51	2.74	2.66
Check	Yes.	1.17	1.00	1.23	1.16	2.10	2.77	2.95
Stable manure at 20 tons per ha	Yes.	1.10	1.08	1.47	1.31	1.96	2.56	3.00
Commercial fertilizer (5–10–5) at:								
200 kg per ha	Yes.	1.35	1.14	1.19	1.40	2.23	2.49	2.88
500 kg per ha	Yes.	1.44	1.13	1.43	1.53	2.58	2.97	3.22
800 kg per ha	Yes.	1.56	1.34	1.67	1.56	2.55	2.94	3.57

TABLE 1.—*Showing the average 15-day yield of strawberry as affected by mulch and commercial fertilizers*—Continued

Fertilizers applied	Mulched	Yield every 15-day period						
		Mar. 8–22	Mar. 23–Apr. 6	Apr. 7–21	Apr. 22–May 6	May 7–21	May 22–June 5	June 6–20
Check	No.	1.63	1.75	1.77	1.59	1.75	0.96	.....
Stable manure at 20 tons per ha	No.	2.40	2.20	2.05	2.02	2.06	1.04	.....
Commercial fertilizer at 200 kg per ha	No.	1.93	1.63	1.55	1.88	2.10	1.18	.....
Commercial fertilizer (5–10–5) at:								
500 kg per ha	No.	2.56	1.96	1.74	1.90	2.36	1.46	.....
800 kg per ha	No.	2.20	2.12	1.96	2.03	2.06	1.31	.....
Check	Yes.	3.31	3.02	2.48	2.95	3.90	2.84	0.61
Stable manure at 20 tons per ha	Yes.	3.26	2.90	2.40	3.01	3.51	2.88	0.60
Commercial fertilizer (5–10–5) at:								
200 kg per ha	Yes.	3.28	3.05	2.51	3.08	3.63	3.20	0.69
500 kg per ha	Yes.	3.66	3.37	2.60	3.38	4.04	3.09	0.67
800 kg per ha	Yes.	4.05	3.26	2.25	2.94	3.97	3.21	0.80

TABLE 2.—*Showing the effect of fertilizers on strawberry yield in unmulched plots*

Fertilizers applied	Average yield	Increase over check	Significance of difference	Relative yield
	Kilos	*Kilos*		*Per cent*
Check	16.0+1.17	.....	.....	100
Stable manure at 20 tons per ha	21.2+1.71	5.2+2.07	Slightly significant	133
Commercial fertilizer (5–10–5) at:				
200 kg per ha	19.5+1.51	3.5+1.91	do	122
500 kg per ha	21.4+1.61	5.4+1.99	do	134
800 kg per ha	25.3+2.45	9.3+2.72	Significant	158

TABLE 3.—*Showing the effect of fertilizers on the production of mulched strawberries*

Fertilizers applied	Average yield	Increase over check	Significance of difference	Relative yield
	Kilos	*Kilos*	.....	*Per cent*
Check	31.5+1.64	.....	.....	100
Stable manure at 20 tons per ha	30.8+1.67	0.7+2.34	Insignificant	98
Commercial fertilizer (5–10–5) at:				
200 kg per ha	32.1+1.21	0.6+2.04	do	102
500 kg per ha	35.2+1.32	3.7+2.17	Slightly significant	112
800 kg per ha	45.7+1.33	4.2+2.11	do	113

TABLE 4.—*Showing the effect of mulching on strawberry production*

Fertilizer applied	Average yield		Increase over unmulched	Significance of difference
	Unmulched	Mulched		
	Kilos	*Kilos*	*Kilos*	
Check	16.0+1.17	31.5+1.64	15.5+2.01	Significant
Stable manure at 20 tons per ha	21.2+1.71	30.8+1.67	9.6+2.39	Do.
Commercial fertilizer (5–10–5) at:				
200 kg per ha	19.5+1.51	32.1+1.21	12.6+1.93	Do.
500 kg per ha	21.4+1.61	35.2+1.42	13.8+2.15	Do.
800 kg per ha	25.3+2.45	35.7+1.33	10.4+2.79	Do.

in unmulched plots, while Table 3 shows the effect of some fertilizers on the yield of mulched strawberry. Table 4 gives the effect of mulching on the yield of strawberries.

In the computation of the data, figures on yield from plots A–7, B–7, C–7, D–7, and E–7 were not included. The stand of the plants in these plots was very poor as compared with the rest of the experimental field. This portion of the field was newly leveled as already stated in the first part of this paper.

DISCUSSION OF RESULTS

EFFECT OF FERTILIZERS ON STAND OF CROP

In connection with field observations, it was noted that the plants in the fertilized plots had a tendency to recover earlier from the effect of transplanting. In the general stand of the crop, however, the fertilized plots showed only a slightly better stand; the plants in the fertilized plots were a little darker green in color than those in the unfertilized plots.

THE BEARING PERIOD OF STRAWBERRIES

The date when the first berries began to mature did not vary very much under the different treatments, but the tendency to mature earlier was in favor of the fertilized plots. The first berries began to ripen as early as the beginning of November, 1931, and the regular harvest was started November 24, 1931. The plants remained in bearing until the middle of June, but beginning with the end of May no harvest could be taken from the unmulched plots; the berries were simply full of soil particles because of rain. The excessive rain in June was the limiting factor in the ripening of fruits.

Figure 2 presents in a graphic was the march in the production of berries under all treatments. It is to be seen in fig. 2 that the maximum production was attained about the end of January and first part of February, 1932. There was a decline in yield in the middle of April, due, perhaps, to the dryness of the soil because of the limited supply of irrigation water. From the time the rains began in the latter part of April until the middle of May, the yield of fruits was good. From this time on, the decline was sharp, mainly because of the heavy rain that was then prevalent.

EFFECT OF FERTILIZER ON YIELD

The summarized effect of the different amounts of fertilizers applied are presented in Tables 2 and 3. As seen in these tables, the fertilized plots gave a higher average production

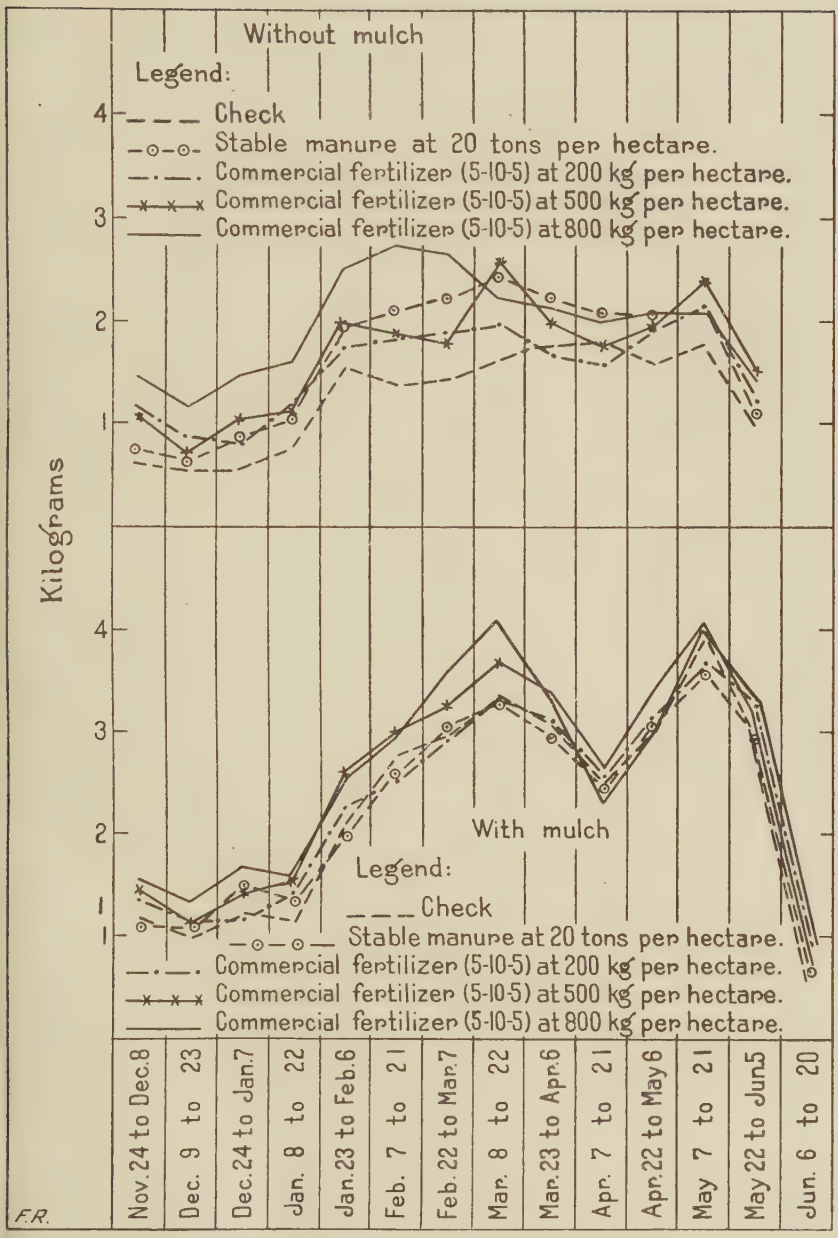
Without mulch
Legend:
Check
Stable manure at 20 tons per hectare.
Commercial fertilizer (5-10-5) at 200 kg per hectare.
Commercial fertilizer (5-10-5) at 500 kg per hectare.
Commercial fertilizer (5-10-5) at 800 kg per hectare.
Kilograms
With mulch
Legend:
Check
Stable manure at 20 tons per hectare.
Commercial fertilizer (5-10-5) at 200 kg per hectare.
Commercial fertilizer (5-10-5) at 500 kg per hectare.
Commercial fertilizer (5-10-5) at 800 kg per hectare.
Nov. 24 to Dec. 8
Dec. 9 to 23
Dec. 24 to Jan. 7
Jan. 8 to 22
Jan. 23 to Feb. 6
Feb. 7 to 21
Feb. 22 to Mar. 7
Mar. 8 to 22
Mar. 23 to Apr. 6
Apr. 7 to 21
Apr. 22 to May 6
May 7 to 21
May 22 to Jun. 5
Jun. 6 to 20
F.R.

FIG. 2. Graph showing the effect of some fertilizers on the march in yield at every 15-day interval of strawberries grown with and without grass mulch.

than the unfertilized or checked plots. The increase in yield, generally speaking, was more or less proportional to the amount of fertilizers applied. The effect of the fertilizers applied was greater in the unmulched plots than in the mulched ones. The increases in yields over the check in the unmulched plots were 33, 22, 34, and 58 per cent respectively for the stable manure, and the 200-, 500-, and 800-kilo applications per hectare of the commercial fertilizers (5–10–5) (see Table 2). In all cases, except in the 800-kilo rate where the average increase in yield over the check was markedly significant, the increases over the check plots were only slightly significant.

In the mulched plots, the effect of the fertilizers was, at best, but small and this was in the case of the 500-kilo and 800-kilo rates per hectare (see Table 3). Even in these plots, the increases in yield were only 12 and 13 per cent respectively over the check plots.

EFFECT OF MULCH ON STAND OF CROP

The effect of the grass and pine leaves mulch on the stand and appearance of the plants was very much more pronounced than that of the different amounts of fertilizers applied. The mulched plots required two weedings as against the nine weedings and cultivatings required for the unmulched plots. The grass mulch suppressed, to a great extent, the development of weeds, aided in the conservation of the soil moisture, and perhaps regulated the temperature of the soil during cool nights. All these factors must have combined to account for the better stand of the plants.

EFFECT OF MULCH ON YIELD

In Table 4 are presented the summarized data on the effect of mulch on the yield of strawberry. The mulched plots, whether fertilized or unfertilized, gave decidedly better average total yields than the unmulched plots. The total average production per 25 square meters in the unmulched plots were 16.0 + 1.17 + 21.2 + 1.71, 19.5 + 1.51, 21.4 + 1.61, and 25.3 + 2.45 kilograms respectively for the check, and the plots treated with 20 tons of stable manure per hectare, and 200-kilo, 500-kilo, and 800-kilo rate per hectare of the 5–10–5 commercial fertilizer. In the mulched plots, the average total production in the same area with the same treatment were 31.5 + 1.64, 30.8 + 1.67, 32.1 + 1.21, 35.2 + 1.42, and 35.7 + 1.33 kilos respectively. The differences in yields between the mulched and unmulched plots were 15.5 + 2.01 kilos for the check plots, 3.6 + 2.39 kilos

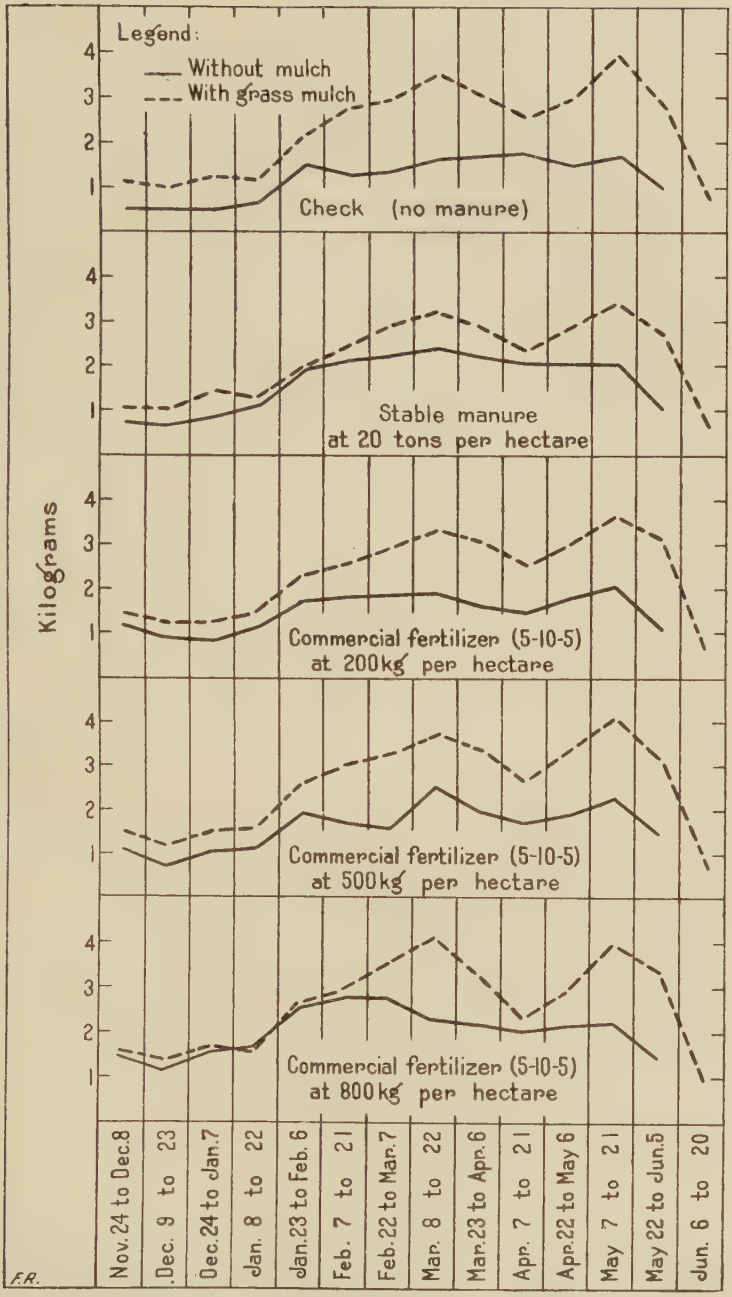
Legend:
Without mulch
With grass mulch
Check (no manure)
Stable manure at 20 tons per hectare
Commercial fertilizer (5-10-5) at 200kg per hectare
Commercial fertilizer (5-10-5) at 500kg per hectare
Commercial fertilizer (5-10-5) at 800kg per hectare
Kilograms
Nov. 24 to Dec. 8
Dec. 9 to 23
Dec. 24 to Jan. 7
Jan. 8 to 22
Jan. 23 to Feb. 6
Feb. 7 to 21
Feb. 22 to Mar. 7
Mar. 8 to 22
Mar. 23 to Apr. 6
Apr. 7 to 21
Apr. 22 to May 6
May 7 to 21
May 22 to Jun. 5
Jun. 6 to 20
F.R.

FIG. 3. Graph showing the effect of grass mulch on the yield of strawberries receiving different amounts of a 5–10–5 commercial fertilizer.

for the plots treated with stable manure at the rate of 20 tons per hectare, and 12.6 + 1.93, 13.8 + 2.15, and 10.4 + 2.79 kilos for the plots treated with 200, 500, and 800 kilos per hectare of commercial fertilizers respectively (see Table 4). In all treatments, the increase in average total production was decidedly in favor of the mulched plots. Figure 3 presents in a vivid way the march of production determined at every 15-day period throughout the whole harvesting season between the mulched and the unmulched plots treated with stable manure and commercial fertilizers (5–10–5) applied at different rates.

Putting on dry grass and pine leaves as mulch gave a decidedly bigger yield than using fertilizers, though of course, the combination of mulch and a heavy application of fertilizers brought about the greatest production in the experiment, an average of 35.7 + 1.33 kilos for a 25-square meter plot, or 14,250 kilos per hectare.

EFFECT OF MULCH ON QUALITY OF FRUITS

The quality of the fruits from the mulched plots was far superior to that from the unmulched plots. In the former, the berries did not come in contact with the ground; this was not so in the latter case. In the mulched plots, berries were picked anytime of the day (early in the morning and just after a rain) and the harvest was free from dirt; such harvest in the unmulched plots were full of soil.

It was further observed that the attack of some fruits rots was decidedly more marked in the unmulched plots. The presence of fruits attacked by fruit rots was more conspicuous when the nights were dewy and the days warm.

No figures were secured as to the cost of putting on dry grass and pine leaves as mulch. However, if the frequent weeding and cultivation and irrigation necessary to maintain the unmulched plots are taken into consideration, the mulching process was certainly cheaper. It may be remarked in passing that at the close of the bearing period of the strawberry, the grass mulch was decayed, ready for plowing under to supply humus in the soil.

SUMMARY OF CONCLUSIONS

1. The effect of stable manure and a complete commercial fertilizer (5–10–5) on the production of strawberries was studied. The effect of grass mulch on strawberry production was also included in the study.

2. In the general stand of the crop, the fertilizers used had only a slight effect; the fertilized plants were slightly darker

green in color than the unfertilized ones. On the other hand, the mulched plots, whether fertilized or not, had a better stand of plants.

3. The fertilized plots, taken in general, gave slightly higher yields than the unfertilized plots. The effect of the fertilizers (stable manure included), was more marked in the unmulched plots. In the mulched plots, the effect of the fertilizers was, at best, slightly significant only, and this was in the case of the 500-kilo and 800-kilo rate per hectare.

4. In all cases (fertilized and unfertilized plots), the effect of grass mulch on the yield of strawberries was decidedly good. A combination of mulching and a heavy application of fertilizers effected the greatest increase in production.

5. The berries picked from the mulched plots were much superior to those from the unmulched plots. The berries from the former set of plots were free from soil and dirt. In the mulched plots the picking could be done very early in the morning as well as just after a rain without any fear of getting the berries all full of dirt.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Showing the arrangement of the experimental plots. Plots A served as check; Plots B fertilized with stable manure at 20 tons per ha.; Plots C, D, and E fertilized with a 5–10–5 commercial fertilizer at 200, 500, and 800 kilos per ha., respectively. The shaded plots were not mulched; the rest were mulched with dry grass and pine needles.

2. Graph showing the effect of some fertilizers on the march in yield at every 15-day interval of strawberries grown with and without grass mulch.

3. Graph showing the effect of grass mulch on the yield of strawberries receiving different amounts of a 5–10–5 commercial fertilizer.

THE CHEMICAL COMPOSITION OF CIGARETTES AND CIGARETTE TOBACCO LEAVES OF THE AROMATIC AND NONAROMATIC TYPES

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Very marked differences in the flavor, aroma, and color exist between the locally made Philippine cigarettes and those of the so-called aromatic type of cigarettes represented by well-known American brands. On account of the especially inviting and desirable qualities of the aromatic cigarettes, the great majority of our younger and not a few of the older generation prefer to smoke them. The Philippine importation of aromatic cigarettes has now reached the three and a half million peso mark, while the manufacture of locally produced aromatic cigarettes by foreign firms, using imported aromatic cigarette tobacco leaves either alone or mixed with some of the locally grown cigarette tobacco leaves is becoming quite an industry.

While presumably a great deal of experimental work has been done on the manufacture of aromatic cigarettes, most of these investigations have been carried on by commercial firms, which exercise the greatest care to keep the results of the researches of their scientific staff secret. For this reason, their literary propaganda is conspicuous by the absence of any useful information on the subject.

It therefore becomes important to determine the essential chemical differences in composition between the typical Philippine cigarettes and the imported and locally produced aromatic cigarettes. For blending and other important steps required in the manufacture of aromatic cigarettes, the information to be obtained by such studies is most desirable.

REVIEW OF LITERATURE

The water content of cigarettes as affecting their smoking quality is of great importance. Bogen (1929) states that the moisture of a score of brands of cigarettes as taken from the

package, was found to average 12 per cent. He says further that the inorganic ash content remaining after combustion bears, in general, an inverse relationship to the nicotine content of the tobacco; and that Virginia and Carolina tobaccos contain the highest nicotine content, amounting to 2.5 per cent, West Indian brands 1 per cent, Oriental cigarettes from 1.25 to 1.5 per cent, and the most popular brands from 1.5 to 2.5 per cent. It is probable that the nicotine content of the tobacco is relatively unimportant in relation to its quality. According to Loew (1899) excessive nitrogenous manuring tends to produce a large leaf, of inferior quality containing larger amounts of nicotine. An attempt was made to find the difference between the water, alcohol, ether, and benzene extracts of foreign and Philippine cigarettes by Lava and Etorma (1929) for the purpose of establishing standards of quality. Other investigators conducted chemical analyses of tobacco in relation to its quality. A. Schmuck and Balabuha-Popzowa (1927) arrived at the conclusions that: (*a*) the amount of protein and total nitrogen decrease in the samples of better quality, while the nicotine content and the ash content increase in inferior tobacco; (*b*) the amount of carbohydrates together with that of polyphenols increases in the samples of tobacco of higher quality; (*c*) the ratio of total carbohydrates to the protein is a good index of the quality of tobacco, the higher ratio indicating tobacco of superior quality; and (*d*) that dark colored tobacco contains a greater amount of nicotine, protein, and total nitrogen, and less carbohydrates and phenols than lighter colored tobacco, the latter being therefore superior in quality to the former.

MATERIALS AND METHODS

Five brands of imported cigarettes and eight brands of locally made aromtic cigarettes, eighteen brands of the typical cigarettes, and eighteen varieties of cigarette tobacco leaves were used.

MATERIALS

I. The imported aromatic cigarettes used were as follows: F1, F2, F3, F4, F5.

II. The Philippine-made aromatic cigarettes used were as follows: N1, N2, N3, N4, N5, N6, N7, N8.

III. The Philippine cigarettes used were as follows: N10, N11, N12, N13, N14, N15, N16, N17, N18, N19, N20, N21, N22, N23, N24, N25, N26, N27.

VI. The cigarette tobacco leaves used were as follows:

A. Aromatic (Philippine grown).

1. Virgina Bright.
2. La Union-Sumatra.
3. Sumatra.
4. White Burley.
5. Adcock–Ilagan.
6. Adcock No. 2–La Union.
7. North Carolina Bright Yellow–San Fernando.
8. North Carolina Bright Yellow–Nueva Ecija.
9. Adcock No. 1–Nueva Ecija.
10. Adcock–Alabang.
11. North Carolina Bright Yellow–Ilagan.
12. Adcock No. 2–La Paz, Iloilo.
13. North Carolina Bright Yellow–Alabang.
14. Gold Leaf.
15. Big Warne–Alabang.

B. Native type.

1. Vizcaya–Ilagan.
2. Cebu.
3. Vizcaya Cigar fillers.

METHODS OF ANALYSIS

Water.—A known weight was dried at 10° C. for eight hours, and the loss in weight reported as moisture.

Inorganic matter and sand.—The tobacco was first dried, and a definite weight incinerated over a small Bunsen flame. After all the "volatile carbon" has been expelled the incineration was completed in a muffle furnace heated to a dull red heat, cooled, and the ash moistened with a strong solution of ammonium carbonate, in order to recarbonate the free bases. It was then dried for eighteen hours and weighed.

Sand.—The ash obtained as just explained was treated with hydrochloric acid (1:6), filtered, the residue dried, ignited and weighed. Another method was to treat the ash with concentrated hydrochloric acid, evaporate to dryness, heat to 150°C. for half an hour, treat with dilute hydrochloric acid (1:12), filter, dry the residue, ignite and weigh.

Nicotine: Silicotungstic acid method for the determination of nicotine.—Silicotungstic acid solution: Prepare a 12 per cent solution of the silicotungstic acid having the following formula: $4H_2O.SiO_2$, $12WO_3 22H_2O$.

Sodium or potassium hydroxide solution (1:2), and dilute hydrochloric acid (1:4) were also necessary.

Nicotine.—Such a sample was weighed as would contain preferably between 0.1 and 1.0 gram of nicotine (if the sample contained very little nicotine, about 0.1 per cent, that amount must not be increased to the point where it would interfere with the distillation). The tobacco was washed with water into a 500 cc round-bottomed distillation flask, a small amount of paraffin and a few pieces of pumice were added to prevent frothing; and a slight excess of sodium or potassium hydroxide was added, using phenolphthalein as an indicator. It was steamed and distilled rapidly through an efficient condenser and the distillate collected into a flask containing 10 cc of the dilute hydrochloric acid by means of an adapter. When the distillation was proceeding very nicely the distillation flask was heated to reduce the volume of the liquid as far as practicable without jarring or undue separation of insoluble matter. The distillation was continued until the distillate showed no opalescence when treated with a drop of the silicotungstic acid and a drop of the dilute hydrochloric acid. The alkalinity of the residue was confirmed with a small amount of phenolphthalein solution. The distillate was concentrated on a hot plate and the volume made up to 500 cc. If not clear, the solution was filtered. One hundred cc of the filtrate was transferred into a 250 cc beaker and 3 cc of the dilute hydrochloric acid was added. An excess of the silicotungstic acid was added to insure a complete precipitation of the nicotine and the whole was allowed to stay overnight or longer until the precipitate was crystalline in form. The precipitate was filtered using an ashless filter paper, washed with cold dilute hydrochloric acid and ignited in a weighed platinum crucible until all the carbon was removed. Finally it was heated in a Tecler Meker burner for not more than ten minutes. The weight of the residue multiplied by 0.114 gives the weight of the nicotine.

Reducing sugar.—Five grams of the tobacco was weighed and extracted with boiling water for one hour. The beaker was covered with a watch glass and the water lost through evaporation replaced from time to time. The mixture was transferred to a 500 cc volumetric flask, thoroughly cooled, and the volume made up to the mark and then filtered.

Twenty-five cc of each of the $CuSO_4$ and alkaline tartrate solutions (Fehling solution) were transferred into a 500 cc alkali-resistant beaker to which was added 50 cc of the prepared filtrate. The beaker was heated on a piece of asbestos gauze over

a Bunsen burner. The flame of the Bunsen burner was previously regulated so that the boiling began in exactly four minutes. The boiling was continued for 2 minutes. (To regulate the burner for this purpose a preliminary test was made using 50 cc of the reagents and 50 cc of water). The beaker was covered with a watch glass during the heating. After heating the hot solution was immediately filtered through an asbestos mat in a porcelain Gooch crucible, using suction. The precipitate was washed with water at a temperature of 60°C. and the Cu_2O residue dried and weighed.

Sucrose.—Fifty cc of the filtrate from the reducing sugar determination was transferred into a 100 cc sugar flask and 1 cc of 1:1 hydrochloric acid was added. The flask was heated in a water bath to 70°C. and 10 cc of 1:1 hydrochloric acid added. The solution was allowed to air cool for thirty minutes, and was then cooled under running water to room temperature. It was diluted to the mark and filtered. The filtrate was used for the reducing sugar determination. The amount of invert was found with the aid of the Munson and Walker's table. Deduct the percentage of invert sugar obtained before inversion from that obtained after inversion and multiply the difference by 0.95 to obtain the percentage of sucrose.

Starch.—Five grams of the tobacco were weighed and 100 cc of water were added. After one hour's filtering, it was finally washed with 250 cc water. The washed tobacco was transferred with 200 cc water into a 500 cc Florence flask and 20 cc HCl sp. gr. 1.125 added. The mixture was then digested for two and one-half hours using a reflux condenser. After the digestion the residue was filtered into a 500 cc volumetric flask and washed complete, combining the filtrate and washing. The solution was neutralized with 40 per cent sodium hydroxide, cooled and made up to the mark.

It was filtered and the reducing sugar determined. The weight of the reducing sugar multiplied by 0.90 gives the weight of the starch.

Nitrogen.—One gram of sample was weighed and transferred into a 500 cc Kjeldhal flask with 30 to 40 cc concentrated H_2SO_4. Ten grams of salt mixture composed of 10 parts of K_2SO_4 and 0.5 part of $CuSO_4$ were added and the contents of the flask digested until the mixture was colorless or nearly so. After cooling, the contents of the flask were diluted with water and connected with the condenser. After adding an excess of saturated NaOH the mixture was distilled into the standard acid. The

excess of acid was titrated with the standard alkali, using methyl red as indicator. From the amount of acid used calculate the per cent of N_2.

DISCUSSION OF RESULTS

Table 1 contains the analysis of five brands of imported aromatic cigarettes. In the moisture analysis there is a fairly noticeable variation in the cigarette analyzed ranging from 10.53 per cent for F2 to 16.53 per cent for F5. F3 has an ash content of 10.96 per cent as against a maximum of 12.62 per cent obtained from F2. However, the F5 upon analysis gave 1.82 per cent sand and 3.75 per cent for F3. The nitrogen analysis shows a very slight variation, F1 analyzing a minimum of 1.82 per cent as compared to F3 which has a nitrogen content of 2.67 per cent. Again, F3 has a minimum content of nicotine which 1.16 per cent while F5 produces 3.09 per cent. The starch varies from 7.40 per cent obtained from F3 to 9.61 per cent from F5. A marked difference exists in the water soluble reducing sugar. The maximum is 11.10 per cent which is for F4 and a minimum of 3.06 per cent for that of F5. F1 has 0.90 per cent of sucrose as against a maximum of 2.30 per cent for F3.

Table 2 shows the analysis of eight Philippine-made aromatic cigarettes. The differences existing in the moisture analysis of these cigarettes are considerable, ranging from a minimum of 6.63 per cent for N2 to a maximum of 14.72 per cent for N3. The ash content is more or less uniform, the minimum being 9.81 per cent for that of N8 as against 13.85 per cent of F5. The N5 brand has a high sand content of 4.04 per cent, compared with 1.51 per cent for N8, giving an average of 2.45 per cent. Excepting N1 and N2, all the other brands of cigarettes have a more or less uniform nitrogen content, the average on the whole being 2.08 per cent. The nicotine content of N8 is rather distinct, it being 2.86 per cent as compared to 1.36 per cent for N3 or with the average of 2.16. Moreover, N2 has a starch content of 10.13 per cent against N8 which is 6.71 per cent. For the water soluble reducing sugar the N3 was found to contain 12.86 per cent, this being the maximum and the N7 with 5.25 per cent as the minimum or with the average of 8.68 per cent. As to the sucrose content N2 and N4 were found to contain the same amounts with 1.21 per cent as compared to N3 which is as low as 0.33 per cent.

Table 3 shows the analysis of typical made cigarettes. Scrutiny of the table shows that the moisture content of N12 and N13

are 14.24 and 14.02 per cent, respectively. The N18, N22, N24, N27 have a uniform content of slightly over 12 per cent. All the rest have a very marked uniformity or moisture content. The trend of the ash content of all cigarettes analyzed assumed parallel results from 14.36 per cent of that of N10. N19 has a significantly low ash content of 0.42 per cent as compared with the 3.28 per cent of N24. Excepting N11, which has a nitrogen content of 0.44 per cent, all the rest range from 1.51 of N20 and N12 to 2.91 per cent. The N10 was found to contain the minimum amount of nicotine of 0.62 per cent as against 2.02 of N27. The N26 contains about twice as much starch with 13.72 per cent as any of the other native cigarettes analyzed. The water soluble reducing sugar content varies from 0.16 of Katubusan to 3.50 per cent to that of N27. The N16 had only a trace of the water soluble reducing sugars.

Table 4 gives the results on the analysis of 16 important aromatic cigarette tobacco leaves. Parallel results are seen in figures of the moisture content of imported cigarettes, excepting La Union–Sumatra and Sumatra, which are 9.59 and 6.56 per cent, respectively. The ash content varies from 7.05 per cent for Adcock–Ilagan to 15.49 for Sumatra. Big Warne–Alabang analyses 0.38 per cent sand as against 5.28 per cent for Adcock No. 2–La Paz, Iloilo to 2.86 of that of La Union–Sumatra. The nicotine analysis varies from 0.22 per cent for Adcock–Ilagan to as high as 5.98 per cent for White Burley. The N. C. B. Y.–Alabang variety has an exceptionally high starch content of 13.32 per cent as against N. C. B. Y.–Nueva Ecija, which is 2.67 per cent. For the water soluble reducing sugar the N. C. B. Y.–San Fernando analyzed 1.83 per cent as against 18.20 for Adcock–Ilagan.

Table 5 shows the analysis of three native cigarette tobacco leaves. The moisture content of the three varieties analyzed has a maximum in the Vizcaya of 13.37 per cent and a minimum of 9.59 per cent in the Cebu. The moisture of the Vizcaya Ilagan, which is 11.80 per cent, averaged about 11.59 per cent. The ash content is more or less uniform. The Vizcaya (cigar filler) variety analyses 1.45 per cent sand as against 5.39 per cent of Cebu. The nitrogen content of the Vizcaya–Ilagan, Isabela; and Cebu are nearly uniform, with 3.93 and 3.45 per cent respectively. The Vizcaya (cigar filler) has only 1.84 per cent. The nicotine of Vizcaya (cigar filler) is rather low as against Cebu, which is 3.03 per cent. Cebu has a maximum starch content of 13.36 while the Vizcaya (cigar filler) has 8.35.

Only the Vizcaya–Ilagan, Isabela variety contains water soluble reducing sugar of 4.40 per cent.

Table 6 gives the average of the analysis of the different makes of cigarettes and cigarette tobacco leaves. Between the Philippine and the imported aromatic cigarettes there are wide differences in some analysis, and small difference in others. A very great difference is most noticeable in the water soluble reducing sugar. The native cigarettes analyzed on the average 0.86 per cent while the imported aromatic cigarettes gave as high as 6.78 per cent or a difference of 5.92 per cent. The result of the nicotine analysis is very interesting. The native cigarette, due to its deep brown color, and poor aroma would be expected to yield more nicotine than the aromatic tobacco used in the imported cigarettes. However, the contrary proved true. The nicotine content of the Philippine cigarettes on the average is only 1.12 per cent as compared with that of the imported cigarettes, which is 2.27 per cent. The ash analysis for both cigarettes shows also a very marked difference. While the imported has an ash content of 11.78 per cent the Philippine cigarettes showed 16.70 per cent. The reverse is true for moisture. The imported aromatic has 13.93 per cent, which is 2.15 per cent more than that obtained from Philippine cigarettes. The starch shows a moderate variation. The imported cigarette yielded 8.12 per cent and the Philippine cigarette 6.41 per cent. A small difference exists in the nitrogen. The imported aromatic cigarette gave 2.07 per cent, against 2.41 per cent obtanied from the Philippine cigarettes. The imported cigarettes analyzed 2.58 per cent while the Philippine cigarettes gave 1.23 per cent.

Aside from the moisture analysis the differences in composition between the typical and the Philippine-made aromatic cigarettes is parallel to that existing between the typical and the imported aromatic cigarettes. The Philippine cigarettes have 11.78 per cent, which is 0.03 per cent higher than that obtained from the imported aromatic cigarettes. The Philippine cigarettes have a fairly high percentage of ash, 16.70, as compared with 11.85 per cent obtained from Philippine-made aromatic cigarettes. Moreover, the Philippine-made aromatic cigarettes analyzed 2.45 per cent for sand which is 1.22 per cent more than the native cigarettes. The nitrogen, on the other hand, does not show much difference, being 2.41 per cent for Philippine cigarettes and 2.08 for Philippine-made aromatic cigarettes. Again, the nicotine of the Philippine-made aromatic is higher, being

2.16 per cent as against 1.12 per cent for Philippine cigarettes. Not a very pronounced difference exists between the starch analyses. The Philippine-made aromatic cigarettes gives 8.03 which is 1.62 per cent more than that obtained from the Philippine cigarettes. A very striking difference is manifested in the water soluble reducing sugar; a fairly high content of 8.68 per cent from the Philippine-made aromatic cigarettes as against the significantly low figure of 0.86 from the native cigarettes. The Philippine cigarettes did not give any sucrose upon analysis, while the Philippine-made aromatic cigarettes have 0.79 per cent.

SUMMARY

The trend of analysis on the imported aromatic and Philippine aromatic cigarettes has a very distinct parallelism, the differences being small in the majority of the analyses. The Philippine non-aromatic cigarettes show remarkably distinct differences in some of the constituents of the results obtained from the imported aromatic and the Philippine-made aromatic, cigarettes. In several analyses the imported aromatic cigarette tobacco leaves showed marked differences from the native cigarette tobacco leaves.

TABLE 1.—*Analysis of imported aromatic cigarettes*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble sugars	
Accession No.	Name							Reducing	Sucrose
Ac–32–11...	F 1.....	13.63	12.26	2.96	1.82	2.20	8.31	6.32	0.90
Ac–32–13...	F 2.....	10.53	12.62	2.65	1.49	2.11	7.44	8.27	2.07
Ac–32–34...	F 3.....	13.48	10.96	3.75	2.67	1.16	7.40	7.14	2.30
Ac–32–65...	F 4.....	15.72	11.57	2.61	2.18	2.77	7.85	11.10	2.11
Ac–32–67...	F 5.....	16.53	11.41	1.81	2.17	3.09	9.61	3.06	0.29
Average....	.....	13.98	11.78	2.58	2.07	2.27	8.12	6.78	1.35

TABLE 2.—*Analysis of Philippine-made aromatic cigarettes*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble sugars	
Accession No.	Name							Reducing	Sucrose
Ac–32–12...	N 1.....	11.93	11.07	2.94	1.51	2.72	7.29	6.41	1.21
Ac–32–14...	N 2.....	6.63	11.30	2.72	1.89	2.74	10.13	6.96	1.07
Ac–32–28...	N 3.....	14.72	12.86	2.00	2.04	1.36	8.22	12.86	0.33
Ac–32–29...	N 4.....	9.84	11.27	2.02	2.20	2.08	.....	9.32	1.21
Ac–32–30...	N 5.....	12.30	12.23	4.04	2.10	1.92	.....	8.20	0.13
Ac–32–64...	N 6.....	14.66	12.42	2.47	2.61	1.74	8.41	5.25	.....
	N 7.....								
Ac–32–66...	N 8.....	12.52	9.81	1.51	2.17	2.86	6.71	10.35	0.78
Average....	.....	11.75	11.85	2.45	2.08	2.16	8.03	8.68	0.79

TABLE 3.—*Analysis of typical cigarettes*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble reducing sugar
Accession No.	Name							
Ac–32–35	N 10	10.70	19.14	1.16	2.52	0.62	6.13	0.28
Ac–32–36	N 11	10.08	19.13	0.85	0.44	0.82	6.19	2.55
Ac–32–37	N 12	14.24	14.38	2.06	2.91	0.81	5.71	0.18
Ac–32–38	N 13	14.02	16.60	2.78	2.48	0.87	5.08	0.16
Ac–32–39	N 14	9.12	18.22	1.13	2.76	0.60	5.14	0.57
Ac–32–40	N 15	10.80	17.72	0.65	2.69	1.26	6.58	0.55
Ac–32–41	N 16	10.25	18.02	0.67	2.62	0.59	6.82	Trace
Ac–32–42	N 17	11.36	17.30	0.60	2.40	0.91	6.39	0.96
Ac–32–43	N 18	13.18	14.88	2.02	2.89	1.34	5.28	0.18
Ac–32–44	N 19	12.20	15.68	0.42	1.58	1.34	5.82	1.43
Ac–32–45	N 20	11.45	15.95	0.53	1.51	1.46	6.11	1.11
Ac–32–46	N 21	11.09	16.82	0.94	2.51	1.23	6.11	0.92
Ac–32–47	N 22	13.74	14.28	1.49	2.70	1.52	6.30	0.28
Ac–32–48	N 23	10.69	17.85	0.78	2.67	0.62	5.96	1.09
Ac–32–49	N 24	13.04	18.04	3.28	2.28	1.53	6.26	0.47
Ac–32–50	N 25	11.72	15.03	0.93	2.90	1.27	5.75	0.93
Ac–32–51	N 26	11.25	15.74	1.04	2.95	1.36	13.72	0.35
Ac–32–52	N 27	13.09	15.76	0.85	2.53	2.02	5.97	3.50
Average		11.78	16.70	1.23	2.41	1.12	6.41	0.63

TABLE 4.—*Analysis of imported aromatic cigarette tobacco leaves*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble reducing sugar
Accession No.	Name							
Ac–32– 8	Virginia Bright	17.23	12.21	3.55	2.01	3.00	.....	8.38
Ac–32– 9	La Union Sumatra	9.59	15.16	2.25	2.86	.....	.....	4.06
Ac–32–10	Sumatra	6.56	15.49	5.28	2.60	1.60	.....	6.87
Ac–32–27	White Burley	12.43	11.14	4.07	2.78	5.98	6.35	10.08
Ac–32–53	Adcock–Ilagan	18.59	7.05	0.75	1.85	0.22	.....	18.20
Ac–32–54	Adcock No. 2–La Union	12.99	15.28	3.12	2.72	0.51	3.93	2.56
Ac–32–55	N. C. B. Y.–San Fernando	13.19	15.15	3.81	2.51	1.17	3.28	1.83
Ac–32–56	N. C. B. Y.–Nueva Ecija	11.84	13.82	4.02	2.22	1.69	2.67	14.09
Ac–32–57	Adcock No. 1–Nueva Ecija	12.12	12.10	4.42	1.48	0.85	8.69	9.06
Ac–32–58	Adcock–Alabang	15.57	12.82	8.72	2.27	1.12	5.77	7.35
Ac–32–59	N. C. B. Y.–Ilagan, Isabela	16.00	8.78	0.94	1.92	1.34	2.27	12.25
Ac–32–60	Adcock No. 2–La Paz, Ilo-ilo	12.16	13.07	1.41	1.38	0.26	9.34	13.98
Ac–32–61	N. C. B. Y.–Alabang	12.93	9.78	0.96	1.72	1.46	13.32	9.32
Ac–32–69	Gold Leaf	17.87	9.19	0.66	.....	1.85	4.89	3.54
Ac–32–70	N. C. B. Y.–Alabang	15.93	10.44	0.65	.....	1.78	6.40	3.20
Ac–32–71	Big Warne–Alabang	16.53	9.75	8.38	.....	1.95	.....	.....
Average		13.84	11.95	2.31	1.77	1.65	6.63	8.32

TABLE 5.—*Analysis of native cigarette tobacco leaves*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble reducing sugar
Accession No.	Name							
Ac–32–62	Vizcaya–Ilagan, Isabela	11.80	16.04	2.29	3.93	1.12	11.49	4.40
Ac–32–63	Cebu	9.59	17.51	5.39	3.43	3.01	13.36	.....
Ac–32–68	Vizcaya (cigar filler)	13.37	17.91	1.45	1.84	0.57	8.35	.....
Average		11.59	17.15	3.04	3.07	1.57	11.07	1.47

TABLE 6.—*Summary table*

Analysis	Imported aromatic cigarettes	Philippine aromatic cigarettes	Philippine non-aromatic cigarettes	Cigarette tobacco	
				Imported	Native
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Moisture	13.93	11.75	11.78	13.84	11.59
Ash	11.78	11.85	16.70	11.95	17.15
Sand	2.58	2.45	1.23	2.31	3.04
Nitrogen	2.07	2.08	2.41	1.77	3.07
Nicotine	2.27	2.16	1.12	1.65	1.57
Starch	8.12	8.03	6.41	6.63	11.07
Water reducing sugar	6.78	8.68	0.86	8.32	1.47
Sucrose	1.35	0.79	.....	.....	.....